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## MINING & METALLURGICAL SECTION

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# SOME REMARKS UPON THE CRITICAL POINTS OF STEEL, THEIR METHOD OF DETERMINATION AND THE VALUE OF SAME.

BY
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IT has been observed that when a piece of high carbon sheet steel is heated to a high temperature, 800° C. or more, and allowed to cool slowly in the dark, the outer portions radiating the heat more rapidly cool faster until a certain temperature is attained when suddenly the outer portions glow more brightly, showing a marked increase in temperature. This phenomenon is termed recalescence (see Fig. 1), and to the temperature at which this occurs the term *recalescent point* has been given. It constitutes one of the critical points in steel, and since it takes place in the cooling (*refroidissant*) it has been designated by the symbol $Ar^1$ to distinguish it from the other slighter and less marked points which are designated $Ar,^2$ and $Ar^3$ respectively.

This phenomenon of recalescence is produced by the evolution of latent heat which accompanies the transformation of the

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mineralogical constituents of the steel as it cools. In heating, the action is reversed, accompanied by an absorption of heat, which while it cannot be so clearly illustrated, can readily be detected. To the points at which these absorptions occur, the symbols Ac,[1] Ac,[2] Ac[3] are applied. "A" is a designation common to both heating and cooling critical points. The "c" is taken from the French *chauffant,* heating. Steel, then, when being heated or cooled passes through transformations termed critical points where there are retardations in the rate of heating and cooling due to some chemical or physical changes within it.

FIG. 1*a*.

*a*. The normal cooling of a plate of high carbon steel the temperature of which is above or below the recalescent point.

FIG. 1*b*.

*b*. The condition during recalescence. The shaded portions are the cooler. In *b* the condition is the reverse of *a*.

A number of methods have been developed for the determination of these and in the *Bulletin of the Bureau of Standards*, vol. v, No. 2 (1908), Burgess presents the following methods:

TEMPERATURE—TIME CURVES.

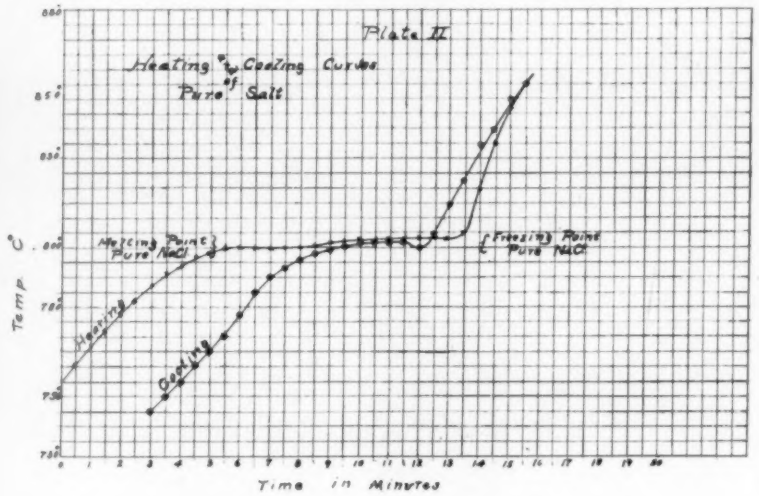
Under this general head two classes or kinds are distinguished.

*Class* I.—In this class simultaneous measurements are made of the temperature of the heating and cooling substance as determined by thermo-electric means, and of the time. The results are plotted in a curve upon which the critical points of magnitude are clearly marked. (See Fig. 2, which shows the melting and freezing points of pure salt.)

Instead of observing the measurements and plotting a curve there are several self-recording instruments of various types, among which may be mentioned that of Bristol, of Leeds & Northrup, of Taylor & Co., and of Queen & Co., in this country. These instruments make an autographic record of the results.

This method, however, is not adapted for the detection of critical points, such as allotropic transformations, which are slight in their effects and take place rapidly. Furthermore, outside conditions, such as accidental changes in the rate of

FIG. 2.

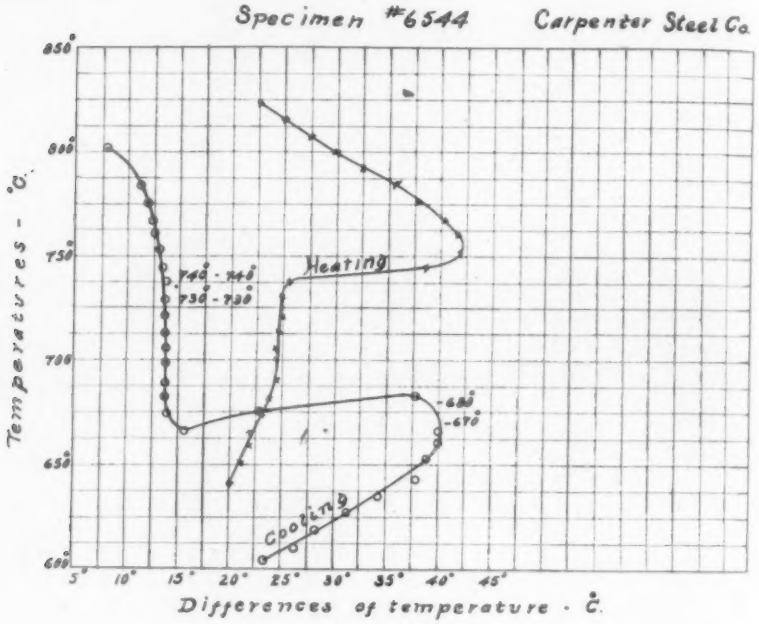



heating and cooling due to an irregular source of heat or air drafts, together with progressive heating or cooling in the specimen itself, make the location and extent of the transformations difficult to satisfactorily determine, hence:

*Class* II.—In order to eliminate the latter mentioned difficulties, a second thermo-couple is placed in the furnace and alternate readings are taken of the piece under examination and the furnace. Two temperature time curves are thus obtained by plotting both galvanometer readings side by side or plotting the difference in temperature against the temperature of the specimen under observation. (Fig. 3 gives a heating and cooling curve of this class.)

This method, however, is no more effective in measuring transformations which are slight and rapid than is Class I, since the method of measurement is the same in each.

FIG. 3.



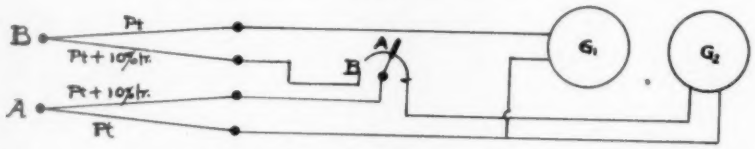

DIFFERENTIAL CURVES.

Under this second general head there are also several kinds.

*Class* III.—If the second thermo-couple be inserted in a neutral body of the same heat conductivity as the sample under observation and the thermo-couple be so arranged as to give a direct measurement of the difference in temperature, more effective measurements of slight transformations are obtained. Figs. 4 and 5 show the necessary arrangements for two such systems. This latter was the system used by Roberts-Austen in investigating the critical points of pure iron while cooling. (See Figs. 6 and 7.) Here the temperature of the specimen *vs.* time is plotted and also the difference in temperature *vs.* time. The thermo-electric measurements of the differential temperatures are more sensitive than those of the temperature of the

specimen, hence there is great sensibility to slight and rapid transformations. From Fig. 7 it is apparent the apparatus of Roberts-Austen, while sensitive, is complicated, and would therefore be difficult of adjustment. It was Saladin of the Creusot Works, France, who invented a method of photographically recording the temperature of the sample and the difference in

FIG. 4.

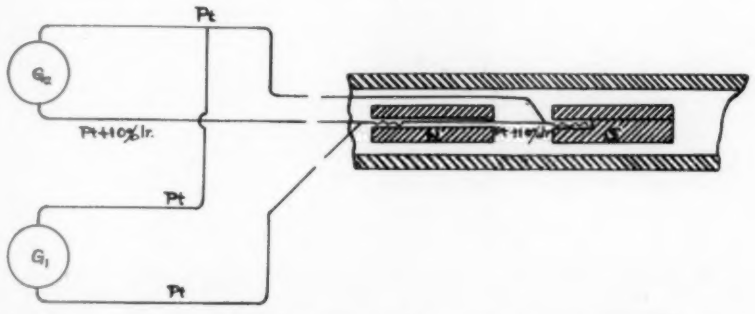



System with commutator in the circuit to enable taking of alternate observations of, the temperature of the furnace and the specimen.

temperature between it and a neutral body whereby the complicated apparatus of Roberts-Austen was eliminated and the desired sensibility obtained.

To the type of curve obtained by this Saladin arrangement, the designation Class IV has been given by Burgess and its function is expressed $\theta$ *vs.* $\theta$-$\theta$ . The details of the Saladin

FIG. 5.



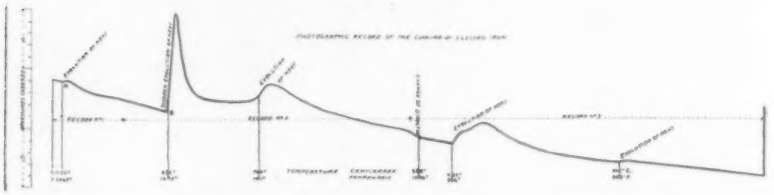

System of Roberts-Austen in which a neutral body is used and the difference in temperature between it and the specimen is determined.

instrument as improved by Le Chatelier are shown diagrammatically by Fig. 8. Fig. 9 shows the instrument as installed at the works of The Carpenter Steel Co. The arrangement of the thermo-couple circuits is shown by Fig. 10.

Burgess describes two more classes (V and VI) but they

have to do with the measurements of the speeds of the transformations and the decrements of temperature in a unit of time and the results are plotted in terms of the temperature. The observations are made after the manner employed in Class II and for sensibility and precision, neither is better than that class.

FIG. 6.



Differential cooling curve of electrolytic iron. (Roberts-Austen, Fifth Report, Alloys Research Committee, Plate II, 1899.) Abscissæ are actual temperatures, and ordinates are the differences, at each temperature, between the temperature of the electrolytic iron and a mass of platinum cooling under identical external conditions. This delicate method reveals even slight evolutions and absorptions of heat.

Fig. 11 shows the curves characteristic of these various methods when working upon

X

substances which remain at a constant temperature during the transformation.

Y

substances which do not remain constant in temperature during the transformation.

Z

substances which increase in temperature during the first part of the transformation.

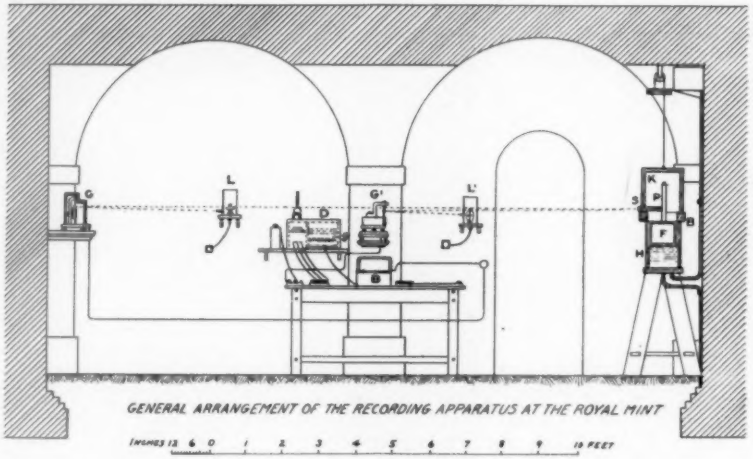
The X type is found in curves for determining the melting points of pure salts. The Y and Z types are met while obtaining the critical points of steel.

Calling attention to some of the characteristics of these curves, it is to be noted that $C$ and $C_2$ are practically coincident and represent the temperatures the piece would have fallen to had the transformation not occurred. Burgess points to the fact "that in general the rate of cooling to the right of $C$ will be greater than to the left of $B$, on account of the furnace walls which having continued to cool during the time $BC$, therefore abstract the heat more rapidly from the specimen." It might well be added, since we will have occasion to note the fact later, that the converse of this happens in heating.

The point of inflection marks the end of the transformation as shown at $C$ in I and $E$ in I′ and I″. Thus there is obtained in the temperature-time curves the beginning, end, and duration of the transformations, together with an approximate measure of the heat evolved, but it must be remembered that in this type of curve these points are difficult to satisfactorily determine for the reasons already given.

In IV, IV′, and IV″, $bc$ is equal to $cc'$ of I, I′, and I″ but the points of inflection $E$ in these do not correspond to similar points in the former figures. Hence this method—temperature *vs.* difference in temperature ( $\theta$ *vs.* $\theta$-$\theta$ )—is less complete although more sensitive than the temperature time curves $\theta$ *vs.* $t$ and those of Classes V and VI.

FIG. 7.

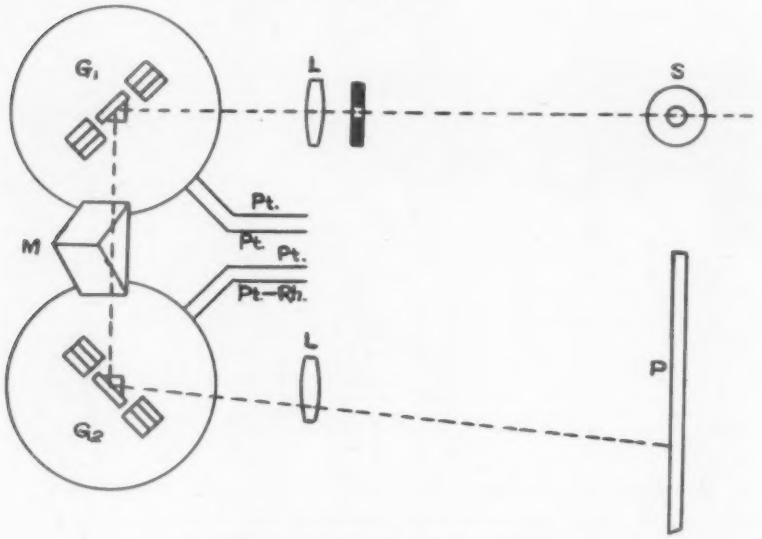



V, V′ and VI″, and VI, VI′ and VI″ represent temperature rate curves. The former—temperature traversed per unit of time *vs.* temperature ($\theta$ *vs.* $\theta$-$\theta$ $dt$)—compare insofar as the transformation points are concerned, with the temperature time curves. $B = B$, $C = C$, $E = E$. The curves shown by VI, VI′, and VI″—temperature *vs.* time elapsed per unit of temperature ($\theta$ *vs.* $\theta$-$\theta$ $dt$ $d$)—are really the reciprocals of V, V′, and V″. Both of these curves show the transformation phenomenon more exaggerated and consequently clearer. As in curves of Class I,

both Classes V and VI are obtained without the aid of a neutral piece to eliminate the effects of outside conditions and hence are less sensitive.

The Saladin-Le Chatelier apparatus offers most to the steel manufacturer, and for this reason it has been installed in the works with which the writer is identified. As already stated this instrument develops curves of Class IV type which are the most sensitive and most certain. Fig. 9 shows clearly the manner of installation. The table carrying the galvanometer is hung by cords from the ceiling. The legs of the table stand in porce-

FIG. 8.




Diagrammatic presentation of Saladin apparatus.

lain battery jars filled with heavy oil. This arrangement enables us to obtain curves that are quite free from exterior disturbances although we are in the second floor of a frame office building subject to the vibrations caused by passing trains, steam hammers, exhaust from mill engines and banging office doors. An electric furnace is used for heating the specimen. Our arrangement of the thermo-couple and the neutral piece of nickel has proven very satisfactory (see Fig. 10), as the curves shown indicate.

FIG. 9.

Saladin apparatus as installed at the works of the Carpenter Steel Co., Reading, Pa.

The location of the end of the transformation which is an important point from a practical and commercial point of view, is said to be difficult in this type of curve. We, however, with

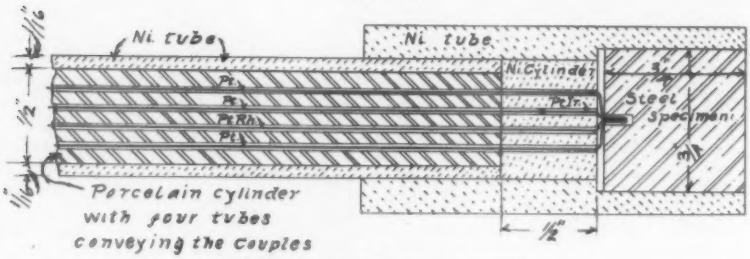
the arrangement just described have been able to locate it with sufficient accuracy for our practical needs.

Consider the curve (Fig. 12) obtained from a steel analyzing:

| | |
|---|---|
| Carbon | .52 per cent. |
| Manganese | 1.20 per cent. |
| Silicon | .17 per cent. |
| Phosphorus | .07 per cent. |
| Sulphur | .06 per cent. |

The arrows indicate the direction in which the ray of light from the mirrors of the galvanometer traversed the plate from right to left in heating and the reverse in cooling. The path is almost a straight line to *b*, at which temperature, 710° C., the specimen begins to convert the heat it absorbs to latent heat

FIG. 10.




Arrangement of specimens and couples.

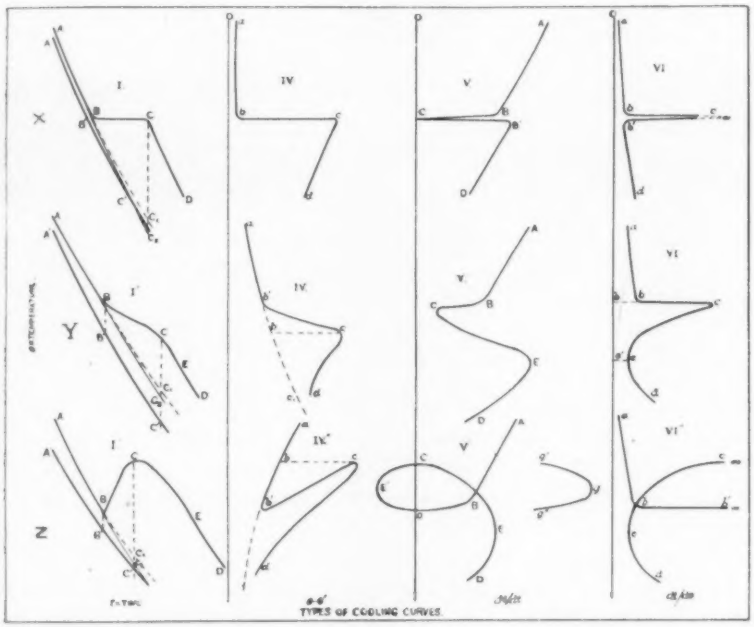
with the result that the neutral which is taking on heat from the furnace, which is uniformly growing hotter, becomes hotter than the specimen. At once there is an electromotive force sent through the differential couple to the first galvanometer and the ray of light is moved upward. At the point *c* the maximum difference in temperature between the specimen and neutral is indicated. While the specimen has been absorbing heat the furnace has been growing hotter so that the specimen having ceased to absorb heat heats more rapidly than the neutral and comes back to equilibrium more quickly upon the completion of the reactions involved in the transformations. This produces the long easy compound curve *cda*. In cooling the differential galvanometer is at zero until *b'*, 663° C., when a slight disturbance takes place. At *b'''* the steel recalesces and there is an increase in temperature of about 6° C. (*b''*) after which

the specimen cools off, giving the curve $b'''d'$. At the point $d'$ the differential galvanometer has come back to zero. We thus have the following points brought to our attention:

In heating $b$ $=710°$ C.
$c$ $=732°$ C.
$d$ $=780°$ C.

In cooling $b'$ $=663°$ C.
$b''$ $=648°$ C.
$b'''$ $=642°$ C.
$d$ $=575°$ C.

FIG. 11.




To ascertain what these temperatures corresponded to in the specimen, sections of the specimen were heated in an electric furnace to 710° C., 725° C., 740° C., 760° C., 780° C., and 800° C. The end of the thermo-couple was inserted into a hole drilled into each and when the desired temperature was attained the section ½ in. round by ⅜ in. thick was quickly quenched in cold brine. These specimens were polished and etched with picric acid (5 per cent.). In etching it was noticed that in order

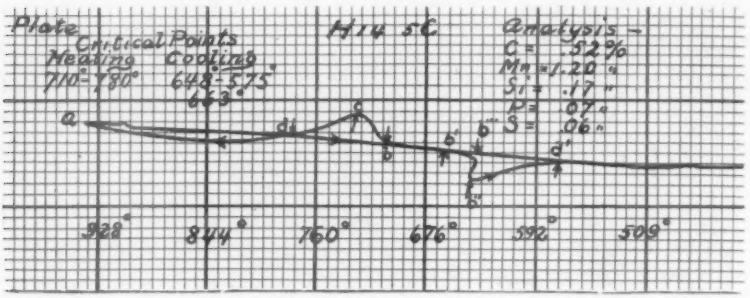
to develop the structures the duration of the immersion for each specimen was:

| | |
|---|---|
| 710° C. | 20 seconds. |
| 725° C. | 20 seconds. |
| 740° C. | 30 seconds. |
| 760° C. | 60 seconds. |
| 780° C. | 60 seconds. |
| 800° C. | 90 seconds. |

The structures are shown by the photomicrographs Figs. 13–17. The Brinell hardness-values of the specimens were also obtained. These results are shown in Table I.

We have already mentioned the points Ac,[1] Ac,[2] and Ac[3] which are more or less widely separated in steels under .34 per

FIG. 12.




cent. carbon, but in steel containing carbon in excess of this amount the points are not to be distinguished one from another in a heating curve. Ac[2] is accompanied by a change of the steel from a magnetic to a non-magnetic condition and Ac[1] is accompanied by a shrinkage but Ac[3] in medium and high carbon steels presents no physical phenomenon whereby it can be located, but it is well known that steel quenched from a temperature at or above this point consists of martensite. From the above table it would appear as if *b*, *c*, and *d* correspond to these three points; *d* is the end of Ac.[3] Whether they do or not is of no great moment practically, since the hardening point of the steel is the all important determination and our experience has shown that steel heated to *d* hardens best. However, it is well known that to obtain the maximum hardness in steel Ac,[1]

$Ac,^2$ and $Ac^3$ must be passed through, hence the point *d* must be just over $Ac,^3$ and $Ac^2$ is between it and $Ac^1$ or *b*. The curve *bcd* then $= Ac^1 + Ac^2 + Ac^3 + I$, in which I equals the

TABLE I

| Specimen quenched from | Position on heating curve | Structural composition | Brinell hardness | Immersion in picric acid | Fracture |
|---|---|---|---|---|---|
| 710° C. | at *b* | Pearlite Ferrite and Sorbite | 146 | 20 sec. | tough |
| 725° C. | between *b* and *c* | Pearlite Sorbite and Ferrite | 131 | 20 sec. | tough |
| 740° C. | above *c* | Pearlite Sorbite and Martensite | 187 | 30 sec. | tough |
| 760° C. | between *c* and *d* | Martensite and Sorbite | 532 | 60 sec.[1] | silky |
| 780° C. | just at *d* | Martensite | lost | 60 sec.[2] | fine crystal. |
| 800° C. | just above *d* | Martensite | 744 | 90 sec.[2] | gran. crystal. |

[1] But 20 sec developed sorbite. [2] No sorbite.

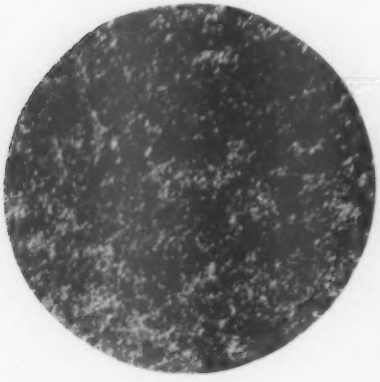
TABLE II

| Specimen* quenched at | Position on cooling curve | Structural composition | Brinell hardness | Immersion in picrid acid |
|---|---|---|---|---|
| 670° C. | just above *b'* | Martensite and Troostite | 418 | 50 seconds<br>10 sec. devel. troostite |
| 650° C. | just under *b'* | Martensite Troostite and Sorbite | 340 | 10 seconds |
| 630° C. | just below *b''* | Sorbite Pearlite, Ferrite Troostite | 179 | 10 seconds |
| 600° C. | near *d'* | Pearlite Sorbite, Ferrite Troostite | 179 | 10 seconds |
| 475° C. | under *d'* | Pearlite Ferrite and Sorbite | 159 | 20 seconds |

*All specimens in this series had been heated to 800° C. and were quenched in brine at the indicated temperatures as they cooled down in the electric furnace. The time of heating to 800° C. occupied 30 or 40 minutes and 15 to 30 minutes were required to cool according to the extent of the cooling.

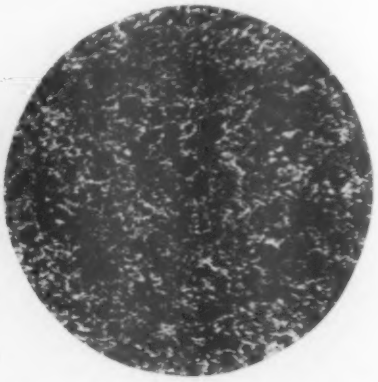
completion of the reactions involved in Ac,[1] Ac,[2] and Ac[3] and the return of the system to equilibrium or nearly so, and I seems to have a small value.

FIG. 13.



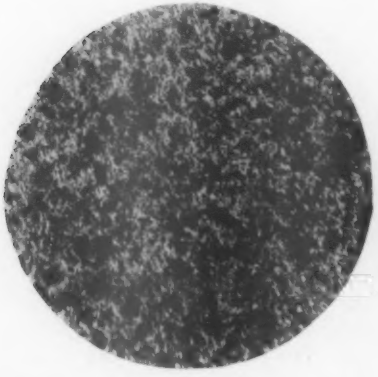
Specimen 1485 quenched from 710°C. Sorbitic pearlite and ferrite $\frac{1}{2}$.

FIG. 14.



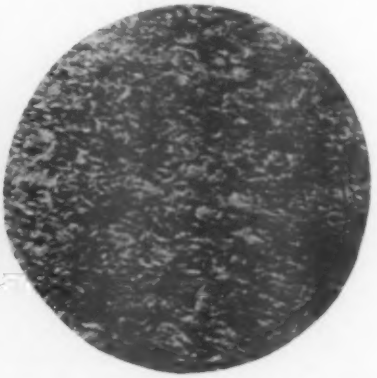
Specimen 1485 quenched from 725°C. Sorbitic pearlite and ferrite $\frac{1}{2}$.

FIG. 15.



Specimen 1485 quenched from 740°C. Sorbitic pearlite and Martensite $\frac{1}{2}$.

FIG. 16.



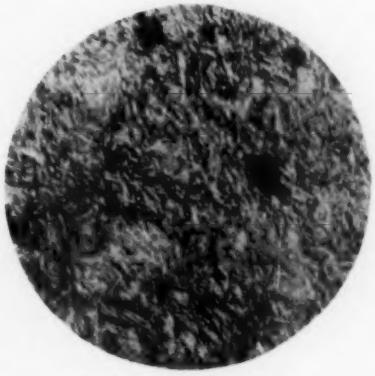
Specimen 1485 quenched from 760°C. Martensite and sorbite $\frac{1}{2}$.

If this condition in heating be true then in the cooling curve beginning at $b'$ through $b''$, $b'''$, and $d$ we would expect to find similar conditions.

To investigate these points the specimens were heated after the manner previously described to 800° C. then let cool to

670° C., 650° C., 630° C., 600° C., and 475° C. respectively, when they were quenched in brine. Figs. 18, 19, 20, 21, 22, 23, and 24 show the photomicrographs of these specimens and the results of the investigations of them is shown in Table II.

FIG. 17.



Specimen 1485 quenched from 780° C. Martensite $\frac{1}{16}$". Specimen 1485 quenched from 800° C.—Same as Fig. 17, but with a more coarse structure.

FIG. 18.

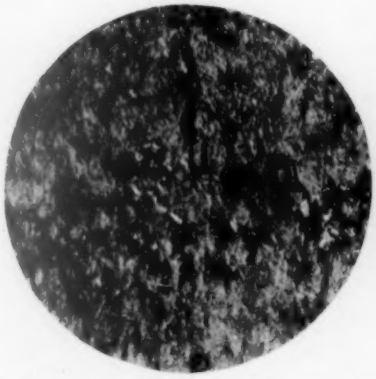
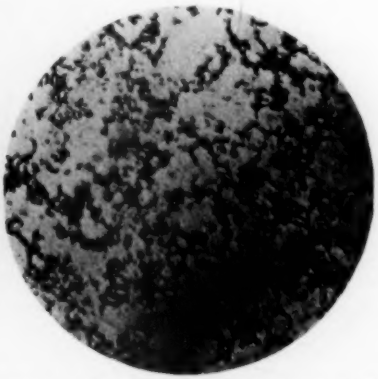


FIG. 19.

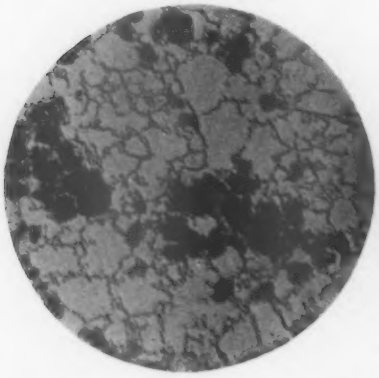


Specimen 1485 quenched at 680° C, cooled from 800° C. Martensite and troostite $\frac{1}{16}$" and $\frac{1}{4}$"

From these results it would seem that the curves *b'*, *b''*, *b'''*, and *d'* covered the range involved in the transformation in cooling as the curves *b*, *c*, and *d* cover it in heating. The dissolution of the minerals formed by heating to 800° C. has not been complete until the temperature of the specimen has

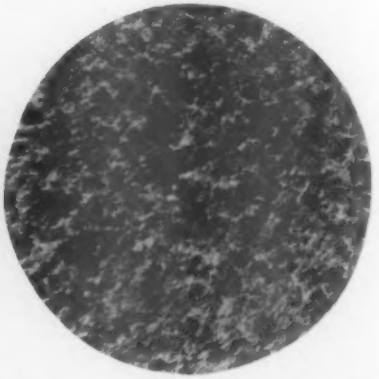
fallen below 600° C. The specimen quenched at 600° C. shows a pearlite pseudomartensite, or sorbite. In this particular curve, which is ideal, points $d$ and $d'$ have been located by the path

FIG. 20.



Specimen 1485 quenched at 650 C., cooled from 800° C. Martensite, troostite and sorbite $\frac{1}{1}^{2}$.

FIG. 21.

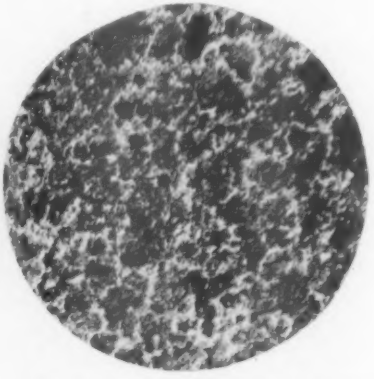


Specimen 1485 quenched at 630° C., cooled from 800° C. Sorbitic pearlite, ferrite and troostite $\frac{1}{1}^{2}$.

FIG. 22.

Specimen 1485 quenched at 630° C., cooled from 800° C. Sorbitic pearlite ferrite and troostite $\frac{1}{1}^{20}$.

FIG. 23.



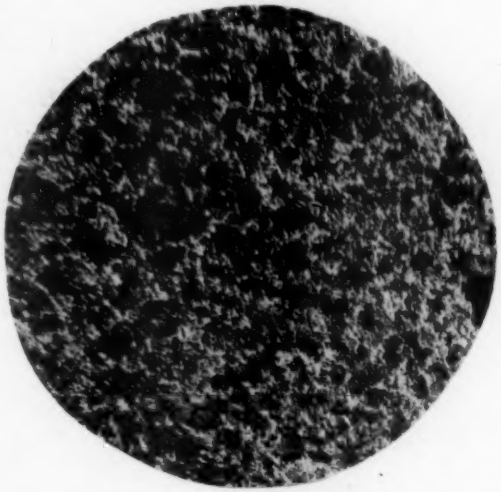
Specimen 1485 quenched at 600° C., cooled from 800° C. Pearlite, sorbite and ferrite troostite $\frac{1}{1}^{2}$.

traced by the spot of light as it traversed the figure, thus in heating the line from $d'$ to $b'$ was traced with the differential galvanometer at zero and so in cooling the differential galvanometer at zero traced the path $db$. In producing this particular

curve the heating required 45 minutes and the cooling 50 minutes under very uniform conditions.

Fig. 25 shows a curve of 1.10 per cent. carbon steel obtained quickly and with no attempt to preserve the most regular conditions. In order to locate *d* the dotted line, a continuation of *a*, *d* and *b* is drawn; *d'* is located through the continuation of *ab'*. Such curves as this particular one are not really to be considered in locating the upper point $Ac^3$ or end of $Ar^1$. This curve has merely been shown to illustrate how the points are located.

FIG. 24.



Specimen 1485 quenched at 475° C., cooled from 800° C. Pearlite, sorbite and ferrite $\frac{1}{2}\frac{1}{2}$.

Fig. 26 is a cooling curve of a .70 per cent. carbon steel and further illustrates how the points *d* and *d'* are determined.

Fig. 27 is of .37 per cent. carbon steel, in it the point *d* is at 825° C.

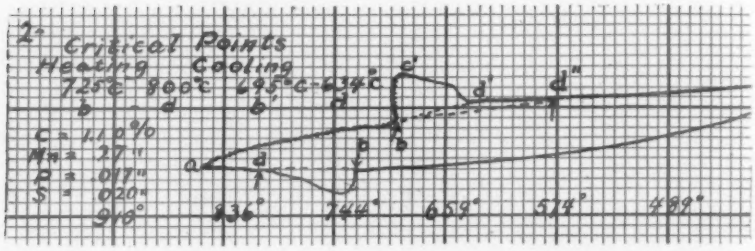
From a study of the heating curves as obtained by us we are enabled to definitely locate for practical purposes the hardening temperatures of our steels and from the cooling curves the proper temperature at which to anneal in order to successfully soften the steels for easy machining or to have them possess certain physical properties.

In a little more than two hours it is possible to have complete

heating and cooling curves of any specimen and a little study of these gives the information which by the old cut and try methods required a very long time, even months. Thus the commercial practical values of these curves are apparent.

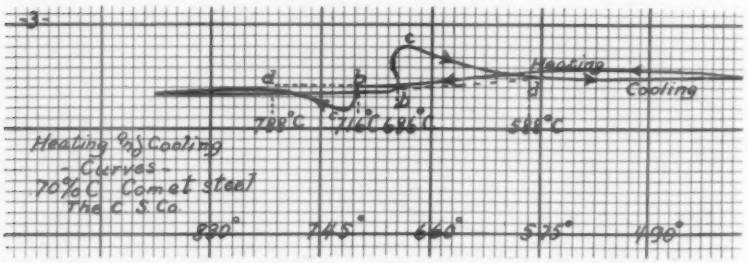
In 1907, the specifications for rifle-barrel steel issued by the

FIG. 25.




ordnance department of U. S. A. specified the determination of the $Ac^1$ point and that tensile test specimens should be cut from samples annealed 10°–20° C. above this point. This specification was developed because in the manufacture of barrels the steel is cut to specified lengths, heated to 600° or 700° C. and

FIG. 26.

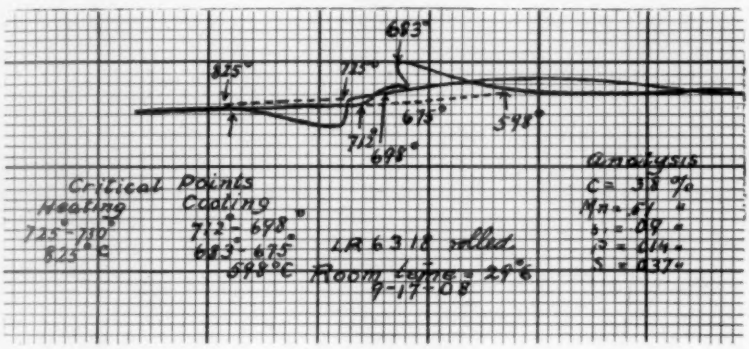



rolled into rifle-barrel blanks, and it was thought that inferior steel could be treated in such a manner that it would meet the requirements specified for the material as it came from the steel mills, and the belief was that the subsequent working of the inferior steel at the arsenal or armory instead of improving the quality depreciated it. By heating the test specimens to above $Ac^1$ before subjecting them to a physical test, any effects of

treatment acquired by heat or rolling would be eliminated, or largely so, and the true quality of the steel made apparent. Thus it will be seen that the determination of the critical points in steel has already been used as part of the specifications for commercial steels.

In what has been presented here, there is no claim to originality except possibly the manner of the location of the points $d$ and $d'$ corresponding approximately to the end of $Ac^3$ and $Ar^1$ and the arrangement of the specimen and neutral.

FIG. 27.




Nowhere has the author seen published curves showing such marked regularity and characteristics as those exhibited with this paper. This regularity might be attributed to the uniform heating of our electric furnace and the arrangement of the specimen and neutral.

All this work has been done at the works of The Carpenter Steel Co., Reading, Pa., with the valuable assistance of Mr. Ben. White and Mr. J. H. Parker. The author wishes to here express his thanks to both these gentlemen and the several others who have kindly aided in enabling this presentation to be made.

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## THE PIG-IRON AND IRON-ORE INDUSTRY IN 1909.

GREAT IMPROVEMENT IN CONDITIONS.

There was a wonderful revival in the iron industry in the United States in 1909, so that the production of both iron ore and pig-iron will nearly reach that of 1907, the year of maximum output up to the present time. Estimates made by E. C. Harder, of the United States Geological Survey, indicate an increase in 1908 of more than 9,500,000 tons of pig-

iron and more than 15,000,000 tons of iron ore. The following table shows the production in long tons of iron ore and pig-iron in 1907 and 1908 and the estimated production for 1909. The figures showing the production of iron ore in 1907 and 1908 were compiled by the United States Geological Survey; those for pig-iron were compiled by the American Iron and Steel Association. The estimates of the production in 1909 were made by examining various trade journals and comparing activities in the various districts with those of previous years.

PRODUCTION OF IRON ORE AND PIG-IRON IN THE UNITED STATES IN 1907 AND 1908 AND ESTIMATED PRODUCTION IN 1909, IN LONG TONS.

| | 1907. | 1908. | 1909. |
|---|---|---|---|
| Pig-iron | 25,781,361 | 15,936,018 | 25,500,000 |
| Iron ore—Lake Superior district | 41,638,744 | 28,225,412 | 41,000,000 |
| Iron ore—Alabama | 4,039,453 | 3,734,438 | 10,000,000 |
| Iron ore—New York | 1,375,020 | 697,473 | |
| Iron ore—other States | 4,667,402 | 3,326,013 | |
| Total ore | 51,720,619 | 35,983,336 | 51,000,000 |

PIG-IRON.

The output of pig-iron increased gradually, with slight fluctuations, throughout the year. In February and in April the production was slightly less than in the preceding months, but except in these two months the increase was steady.

The following table shows the production of pig-iron during the first half of 1909 as estimated by the best authorities:

*Production of pig-iron from January to June, 1909, in long tons.*

| | |
|---|---|
| American Iron and Steel Association | 11,022,346 |
| *Iron Age* (New York) | 10,890,167 |
| *Iron Trade Review* (Cleveland) | 10,820,059 |

The estimates of the *Iron Age* and the *Iron Trade Review* do not include charcoal pig-iron.

The *Iron Age* gives the following monthly production of coke and anthracite pig-iron in long tons from July 1 to December 1, 1909: July, 2,103,431; August, 2,248,930; September, 2,385,206; October, 2,599,541; November, 2,547,508.

On June 30, 1909, out of a total of 436 blast-furnaces 258 were in blast, as compared with 236 on December 31, 1908. By November 1, according to the *Iron Age*, the number had increased to 309 and by December 1 to 314.

IRON ORE.

The increase in the production of iron ore, although distributed over the entire country, was greater proportionally in the Lake Superior district than elsewhere. The lake shipments of Lake Superior iron ore, according to the *Iron Trade Review*, amounted by December 1 to 41,164,359 long tons, which will probably be increased to about 41,500,000 long tons by January 1, 1910, as compared to a total of 25,427,094 long tons during 1908 and 41,290,709 long tons during 1907. The lake shipments for 1909, however, cannot be taken as a measure of the production, since the stock left at the mines in the Lake Superior district at the end of 1908 was greater by several million tons than it had been for some years past, amounting to 5,251,571 long tons, as compared with 2,753,333 long tons at the end of 1907.

The production in New York will probably be somewhat greater than

in 1907, the record year; that in Alabama will probably be about the same as in 1907.

By taking the production in these three districts as a basis and comparing it with the production in various parts of the country in previous years the above estimate of the total iron-ore production in 1909 has been obtained.

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## PRODUCTION OF COPPER IN 1909.

### A RECORD-BREAKING YEAR.

Statistics and estimates received by the United States Geological Survey from all plants known to produce blister copper from domestic ores and from all lake mines indicate that the copper output from mines in the United States in 1909 surpassed all previous records.

The figures, which have been collected by B. S. Butler, of the Survey, represent the actual production of each company for eleven months and include an estimate of its December output. The November figures for a few companies were not available and these companies furnished estimates for the last two months of the year. According to the statistics and estimates received the output of blister and lake copper was 1,117,800,000 pounds, as against 942,570,721 pounds in 1908, an increase of over 18 per cent. This not only exceeds the increase of any previous year but it is considerably greater than the total yearly increase since 1904.

### OUTPUT OF LEADING COPPER-PRODUCING STATES.

It is impossible now to give figures that represent accurately the distribution of the output among the States of origin, but a few general statements may be positively made concerning the leading copper-producing States. Montana shows a large increase, again taking first rank, a place lost to Arizona in 1907. The production in Montana will nearly equal or will possibly exceed the State's previous record output, 314,750,000 pounds, made in 1905. Arizona holds second place, with a slight increase over the 289,523,000 pounds produced in 1908. Michigan also exceeded the 1908 production, 222,289,000 pounds. Large gains were made by Utah and Nevada, and California also increased its output considerably.

### REFINED COPPER.

Statistics showing the output of refined copper by plants in the United States are not now collected by the Geological Survey. Figures published by the Copper Producers' Association indicate that the production of marketable copper from all sources, domestic and foreign, for the first eleven months of 1909 will exceed 1,400,000,000, as against 1,161,176,085 pounds in 1908. Statistics showing domestic deliveries for the first eleven months of the year, as given by the Copper Producers' Association, indicate a consumption of copper in the United States considerably greater than the previous record consumption—682,000,000 pounds, in 1906.

### EXPORTS.

Estimates based on figures for the first eleven months, published by the Bureau of Statistics and also by the Copper Producers' Association, indicate that the exports of copper will surpass by several million pounds the exports for 1908—661,876,127 pounds.

### IMPORTS.

According to the Bureau of Statistics, imports of pigs, bars, ingots, plates, and old copper for the first eleven months amounted to 213,100,281 pounds, and the copper content of ore matte and regulus imported amounted

to 74,708,482 pounds. If the imports for December were equal to the average monthly import for the first eleven months the amount of copper entering the United States for the year was about 311,800,000 pounds, as against 218,705,487 pounds in 1908.

STOCKS.

Stocks of refined copper in the United States show a considerable increase over those of January 1, 1909, but the accumulation occurred for the most part during the first half of the year. European stocks, however, have increased rather uniformly throughout the year and at the close were probably nearly double those of January 1, 1909. The price of copper has remained close to 13 cents throughout the year, the average monthly New York quotation for electrolytic copper being a little under 13 cents.

MINE DEVELOPMENT.

Mine development has been active in most of the important camps, but especially so in the deposits of disseminated ore in Arizona and Nevada. The mines and smelters of the country are now in a position to make the output of 1910 larger than that of 1909. So many factors, however, enter into the determination of the output that any forecast of production of the coming year made at this time would be without value.

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## PRODUCTION OF REFINED LEAD IN 1909.

GEOLOGICAL SURVEY'S ESTIMATES SHOW A RECORD-BREAKING YEAR.

Figures showing the production of refined lead in 1909, compiled without change by C. E. Siebenthal, of the United States Geological Survey, from reports and estimates made by the desilverizers and the soft-lead smelters, are believed to show approximately the actual output within 1 per cent. Figures showing the imports and exports were obtained from the records of the Bureau of Statistics for the first eleven months of the year, and to these have been added estimates for December.

PRODUCTION.

The total production of refined lead, desilverized and soft, from domestic and foreign ores in 1909 was approximately 444,363 short tons, worth at the average New York price $38,215,000, as compared to a production of 396,433 tons in 1908 and 414,189 tons in 1907. These figures do not include an estimated output of 12,860 tons of antimonial lead, as against 13,629 tons in 1908 and 9910 tons in 1907. Of the total production, desilverized lead of domestic origin, exclusive of desilverized soft lead, is estimated at 209,698 tons, as against 167,790 tons in 1908; and desilverized lead of foreign origin comprised 87,379 tons, compared to 97,761 tons in 1908. The production of soft lead from Mississippi Valley ores is estimated at 147,286 tons, as compared with 130,882 tons in 1908 and 129,607 tons in 1907. Missouri apparently retained first place among the lead-producing States.

IMPORTS AND EXPORTS.

There was a slight increase in the imports of lead in ore and base bullion, which amounted to 112,467 tons, value at $4,210,829, as compared to 109,287 tons in 1908. Of the 1909 imports, 102,300 tons, or 90 per cent., came from Mexico. The imports of refined lead increased slightly, being 3588 tons, with a value of $230,956, against 2759 tons in 1908. The exports of foreign lead (lead of foreign origin smelted or refined in the United States) show an increase of 16 per cent., being 88,794 tons, valued at

$3,221,836, compared to 76,367 tons in 1908. The exports of lead manufactures decreased slightly, having a value of about $530,000, as compared to $599,640 in 1908.

PRICES.

The price of lead started in January with an average of 4.2 cents per pound, falling in March to the minimum for the year, 3.95 cents per pound, then rising slowly to the close of the year. The average New York price for the year was 4.3 cents per pound.

## PRODUCTION OF PETROLEUM IN 1909.

DECREASE IN PRODUCTION.

According to reports received by the United States Geological Survey, the remarkable rate of increase in the production of petroleum that extended through 1907 and 1908 was checked in 1909.

The production for the United States in 1909, as estimated by David T. Day, of the Geological Survey, was between 173,000,000 and 178,000,000 barrels, as against 179,572,479 barrels in 1908. The decrease was less than had been expected in view of the great accumulation of stocks during the preceding year. This accumulation occurred entirely in States east of the Rocky Mountains that have no trade connection with California, and this State therefore showed a great gain, in which nearly all its pools participated.

DECLINE IN PRICE.

That the production of 1908 was more than the market could reasonably stand was shown by the decline in price in the eastern and middle fields. The price for Pennsylvania crude oil, which had been $1.78 per barrel, began to decline on May 3, 1909, and had fallen to $1.43 per barrel by December 9. A cut was made in Lima oil from $1.04 per barrel to $0.84 per barrel; in Illinois oil from $0.68 per barrel to $0.60 per barrel; and in the Oklahoma fields the price likewise declined from $0.41 per barrel to $0.35 per barrel.

There were no significant discoveries of new fields during the year, although outside of the well-known regions prospecting was particularly active in Wyoming, Utah, and New Mexico.

## PRODUCTION OF QUICKSILVER IN 1909.

PRELIMINARY STATEMENT BY THE GEOLOGICAL SURVEY.

Statistics collected by H. D. McCaskey, of the United States Geological Survey, from the producers show that the total production of quicksilver in the United States in 1909 was 20,425 flasks of 75 pounds each, valued, at the average New York price in 1909—$46.17 per flask—at $943,022. These figures represent exactly the production for the first eleven months of 1909 plus the estimated production for December. A comparison of these figures with those given by the Survey for 1908—19,752 flasks, valued at $824,146—shows an increase for 1909 of only 673 flasks, but an increase in value of $118,876. The Survey's value for 1908 was based on prices given by producers, however, and not on the average New York price, so that a better idea of relative values would be obtained by comparing the values for both years as determined by the average New York price. Since this price per flask in 1908 was $44.84, the value for 1908, thus computed, would be $885,680, and the increase in value of the quicksilver production of 1909 over that of 1908 would be $57,342.

PRICES.

Prices have steadily risen during the last three years, and unless production should greatly increase will probably remain fairly attractive to producers that are operating at reasonably low costs. In 1907 the average prices per flask for quicksilver were, for New York, $41.50; for San Francisco domestic, $39.60; and for San Francisco export, $38.17. In 1908 these prices rose, respectively, to $44.84, $44.17, and $42.54. In 1909 the corresponding prices rose further, to $46.17, $45.33, and 43.33.

IMPORTS AND EXPORTS.

Figures showing the imports in 1909 are not yet available, but they were probably insignificant, as they have been for several years past. The exports, however, as shown by exact figures obtained from the Bureau of Statistics for the first eleven months, and by an estimate for December, materially increased in 1909. The exports in 1909 were 6900 flasks, valued at $268,972. The corresponding figures for 1908 were 2996 flasks, valued at $124,960; those for 1907 were 5132 flasks, valued at $192,094.

PRODUCTION BY STATES.

The production by States shows a decrease in California from 16,984 flasks in 1908 to 15,700 flasks in 1909; an increase in Texas from 2832 flasks in 1908 to 3925 flasks in 1909; and an increase in combined output from Nevada and Oregon from 346 flasks in 1908 to 800 flasks in 1909. In 1909, for the first time in many years, there was a small production in Nevada, but no production was reported from either Arizona or Utah.

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## PRODUCTION OF SPELTER IN 1909.

GREAT GROWTH OF THE ZINC INDUSTRY.

A statement just issued by the United States Geological Survey shows that the zinc industry in 1909 had a year of unexampled expansion. Not only was the largest output of spelter ever made in the United States almost completely absorbed by the market, but the imports of spelter were much larger than ever before. Local accounts indicate a record-breaking production of zinc ores in the Joplin and upper Mississippi Valley regions and from the Franklin Furnace mines of New Jersey.

The following figures have been compiled without change by C. E. Siebenthal, of the Geological Survey, from reports furnished by all operating zinc smelters, showing their output for the first eleven months of the year and their estimated production in December, and are confidently believed to be within 1 per cent. of the actual output. Figures showing the imports and exports were obtained from the records of the Bureau of Statistics, likewise with estimates for December.

PRODUCTION.

The production of primary spelter from domestic ore in 1909 is estimated at 241,842 short tons, and from foreign ore at 26,373 tons, a total of 268,215 tons, worth at the average price $28,967,220, as compared to 210,424 tons in 1908 and 249,860 tons in 1907. The production of spelter from both domestic and foreign ores, apportioned according to the States in which smelted, was approximately as follows: Illinois, 76,486 tons in 1909, as compared to 50,244 tons in 1908; Kansas, 104,007 tons in 1909 and 99,298 in 1908; Missouri, 8,479 tons in 1909 and 10,201 in 1908; Oklahoma, 28,821 tons in 1909 and 14,864 tons in 1908; Eastern, Western, and Southern States, 50,422 tons in 1909 and 35,817 tons in 1908. The total production

of spelter is equivalent to the output of 56,112 retorts operating continuously through the year, or 60 per cent. of the total smelting capacity.

IMPORTS AND EXPORTS.

The imports of zinc ore exceeded all records, being approximately 116,173 short tons, valued at $1,381,836. Of this amount 91 per cent., or 105,600 tons, was from Mexico, more than double the quantity imported in 1908, which was 53,757 tons, and even more than the quantity imported in 1907, which was 103,117 tons. The exports of zinc ore show a decrease, being 12,456 short tons, worth $412,300, compared to 26,108 tons in 1908. The imports of spelter show a remarkable increase, being approximately 10,961 short tons, worth $947,196, compared to 881 tons in 1908. The exports of spelter fell off slightly, being 2487 tons, as against 2648 tons in 1908. The exports of zinc dross were 7306 tons, valued at $494,158, compared to 8405 tons in 1908.

CONSUMPTION.

The apparent consumption of spelter in 1909 may be calculated as follows: The sum of the stock on hand at the smelters at the beginning of the year, 19,622 tons, plus the imports, 10,961 tons, and the production, 268,215 tons, gives the total available supply, 298,798 tons. From this there is to be subtracted the exports, 2487 tons, and the stock on hand at the smelters at the close of the year (to be exact, on hand December 15), 10,546 tons, a total of 13,033 tons, leaving a balance of 285,765 tons as the apparent consumption. This calculation takes no account of the stocks of spelter held by dealers for speculative purposes. On comparing the consumption in 1909 with the 215,401 tons in 1908, the 228,524 tons in 1907, and the 220,781 tons in 1906, it seems probable that considerable stocks are held by dealers.

PRICES.

Spelter opened at St. Louis in January at 5 cents per pound, but dropped to 4.52 cents per pound late in February. A gradual rise carried prices up to 6.27 cents near the close of the year. The average St. Louis price of prime western spelter for the year was 5.4 cents per pound.

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## CALORIFIC VALUE OF PEAT.

The following interesting information is furnished by the Deputy United States Consul at Cork, Ireland:

The calorific value of 10 tons of peat, freshly dug and untreated, is assumed to equal that of 1 ton of ordinary coal. There are in Ireland 2,800,000 acres of unutilized bog land with a depth varying from 16 to 30 feet. There are 18,231 tons of peat to 1 acre of bog and this would be equivalent to 1823 tons of coal. Accordingly the total calorific value of the bog lands of Ireland is estimated as being approximately equal to that of 5,104,000,000 tons of coal. Moreover, at least half of this quantity could be conservatively counted on as available ultimately for steam-raising purposes. Peat fuel equal to coal could be produced in selected localities in Ireland at $1.75 per ton.

Some authorities maintain that the peat bogs are reproductive, and that in some cases the bogs increase in thickness 5 or 6 inches a year, according to the nature of the flora. This is simply theory, however, and there is doubt as to whether they are recuperative at all. In case reproduction be at all feasible, the life of the bogs as a fuel reserve would, under adequate conservation, be capable of indefinite extension.

# MECHANICAL & ENGINEERING SECTION

(*Stated Meeting held January 6, 1910.*)

## STEEL IN FREIGHT CAR CONSTRUCTION.

BY

**C. A. SELEY,**

Mechanical Engineer, C. R. I. & P. Ry.

[It has been the custom among designers of freight cars either with underframes of steel or of wood to depend upon the strength of the underframe alone in making computations for a specified carrying capacity, despite the fact that the superstructure in many cases can and does constitute a truss. The author presents the evolution in design of structural-steel freight cars, with which he has been closely identified, where the value of the superstructure as a truss has been duly considered as an element of strength and in reducing weight.]

In the history of American railroad-car building and especially of freight cars, it is found that steel did not play an important part as a body material until very recent years. Iron and steel have always been used for bolts, rods, and other fastenings, but wood has been the principal material for the framing, flooring, lining, and roofing of the majority of cars. Wood was first displaced by iron or steel in the truck construction and side frames; cross frames and bolsters have been successively changed so that now wood is seldom found in modern freight-car trucks. In car bodies steel was slower in obtaining recognition and use in lieu of wood; first in bolsters and then gradually into the sills and framing.

There is very little authoritative literature on freight-car construction. It is mainly found in technical journals, club and society proceedings, and the M. C. B. Association standards and rules which have undoubtedly contributed most to the uniformity of car design in its general features.

In the designing of wooden cars, particularly those having superstructures, it was the common practice to provide for the

carrying strength in the underframing and not depending on the superstructure framing for carrying any part of the calculated load. Not only was this the general practice of car designers and builders but the principle has been discussed and approved at Railroad Club meetings which are on record.

The writer could not agree to this theory of design as applied to general car construction. It might be advisable as regards ordinary house cars of wood construction, but with other types of cars, particularly those presenting an unbroken side, such as flat-bottomed or hopper gondolas, there is such an opportunity presented for a truss or a plate girder of proper depth as to give

FIG. 1.

any strength required with a minimum of material. The writer has since found the same principle to apply in house car designs. There was no opportunity to make a demonstration of his belief that the side framing of a car could be successfully used in carrying a considerable proportion of the load until the year 1900, when as Mechanical Engineer of the N. & W. Ry. he designed a steel framing for a 40-ton flat-bottomed, drop-door gondola, using wood for floor, side, and end lining. Five hundred cars were built at that time and twenty-five hundred cars two years later, thoroughly and successfully demonstrating the principle involved.

Photographs showing the design, using channel centre sills,

built-up-body bolsters, and trussed side framing made of standard sections of angles, channels, etc.

Fig. 1 shows a completed car with load and was the first car of this kind and series ever built.

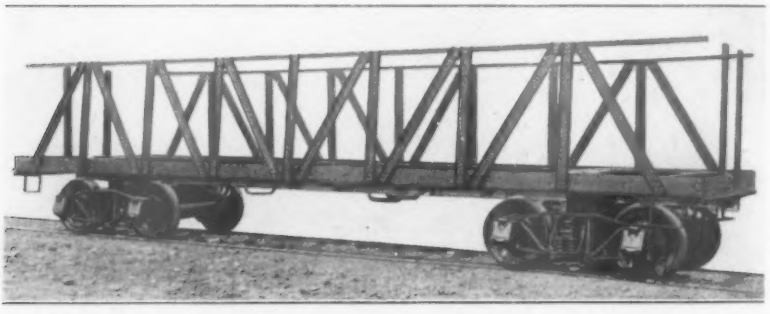
Fig. 2 shows the steel framing before the application of the wood floor and lining as viewed from the side.

Fig. 3 is the same except that the view point is at the end.

Fig. 4 is of another completed car of the same type, but of another series built two years later and on the original drawings. Attention is called to the neat, trim appearance of these cars, the readiness with which they can be inspected, their light weight, yet withal a stiff, staunch construction.

Drawings and description of this car were first published in

FIG. 2.



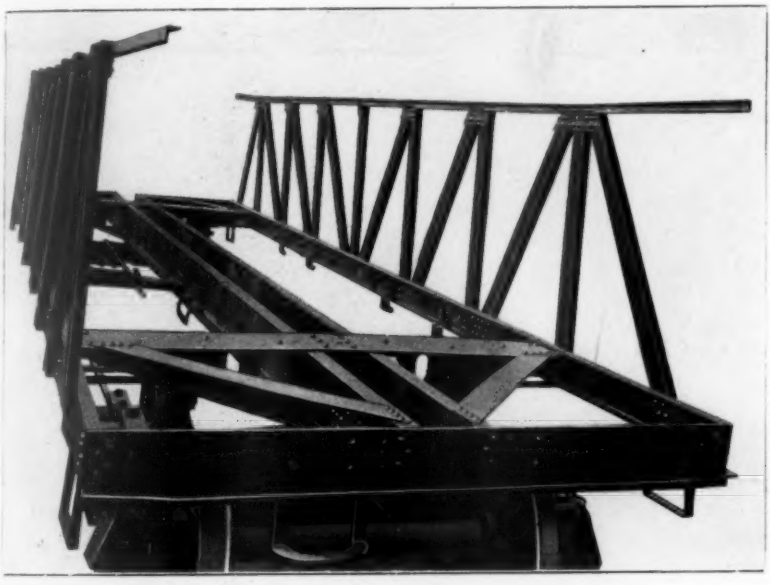
the April, 1900, issue of the *American Engineer and Railroad Journal* and also in other papers.

Following the successful application of the trussed side frame to the flat-bottom gondolas, designs were made for hopper cars which have been copied more or less exactly in many thousands of cars on various railroads. Photographs showing some hopper designs: Fig. 5 is of a steel underframe with wooden stakes and box, designed before my connection with the road owning them and a lot of 1000 were built with which we had some varied experiences. There being nothing on the diagonal except the chute planks, these had to take the full effect of fore and aft movement of the body when shocks occurred in trains of these cars when empty, and we had the fastenings of these planks fail in large numbers, so as to require a modification that

would permit a certain amount of swing. When loaded the wedge effect of the load did not permit the movement which so strongly manifested itself in cars running empty.

After our experience with the trussed-side, flat-bottomed gondolas shown in Figs. 1 to 4, it was determined to apply the principle to the hopper design, which resulted in the car Fig. 6, this photograph being of the first car of the design and series ever built. It will be noted that there is an open centre panel

FIG. 3.



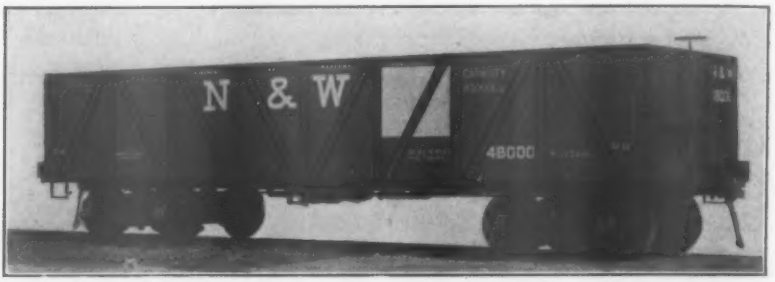
and that several of the vertical members are extended below the bottom chord of the truss to assist in carrying the door supports. The steel frame-work for one of these cars is shown by Fig. 7 as viewed from the side and Fig. 8 as viewed from the end.

Drawings and descriptions were first published in the February, 1901, issue of the *American Engineer and Railroad Journal,* and also in other papers.

The D. & H. Co. copied the truss side feature, but with a different door arrangement; the steel frame is shown by Fig. 9, and a completed car by Fig. 10.

Ordinary bridge truss formulas were used in calculating the foregoing N. & W. Ry. Co. designs and subsequent performance shows these to have been properly used. In 1902 it was deter-

FIG. 4.




mined to build some box cars with complete steel framing, but with wood flooring, lining, sheathing, and roofing. Box cars have side doorways, which do not permit of an uninterrupted truss. The centre panel of the Burr truss of 5 panels which most closely

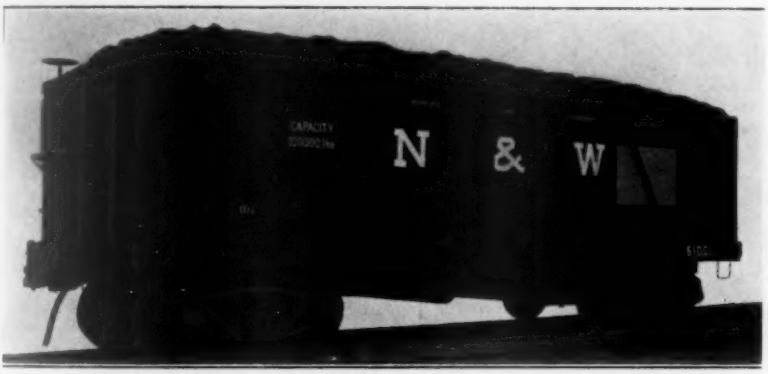
FIG. 5.

approximates car framing is filled with an "X-bracing" which serves to carry over to the other side strains resulting from unsymmetrical loading of the structure. We must, however, leave the side doorways of the box car clear openings and just

how to take care of the shear in case of unsymmetrical loading was first to be settled.

A wooden model of the side frames was made on a scale of 1 inch equal to 1 foot. The posts and braces were notched over sills and plates and the latter was reduced so as to have no strength as through members or sills. A floor was laid and the whole structure mounted on the bolster bearings. A silk line was stretched and marks made for indicating deflection. The floor was then covered with cast-iron washers and although the complete model weighed but 2¾ pounds it sustained over 200 pounds of loading. The load was then removed from the ends which resulted in increasing the centre deflection.

FIG. 6.

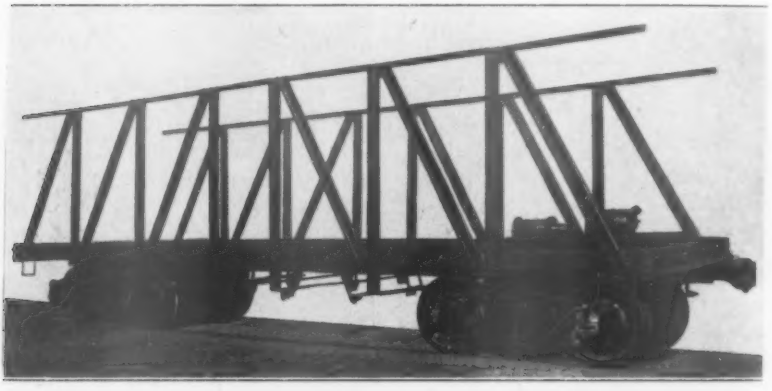



A considerable number of unsymmetrical arrangements of the load were tried and the gauging points on the frame showed the "S" curve indicating shear in the centre panel, but from deductions assumed from the results of these tests, use of some formulas on models and other calculations it seemed as though the "X-bracing" in centre doorways might be omitted if the top and bottom members were slightly reinforced. As a matter of fact, however, the sections used in these side trusses are excessive for the strength required in order to have thickness of material that will stand the waste and corrosion in railway service, and as some of the members are combined in the structure for other purposes as well, it is not difficult to get proper strength to resist shear in the doorway.

The first box cars built after this fashion proved that the calculations were correct and now many thousands of steel-frame box cars, stock cars, and other house cars have demonstrated the feasibility of the design.

I regret not having a photograph of the very first steel-frame box car built from my design, but one from a later series is shown in Fig. 12. This is not as complete as one which will be shown later. The open centre panel at doorway in the sides may be particularly noted. Fig. 13 is of this same frame as viewed from the end, and it will be noticed that in a general way

FIG. 7.



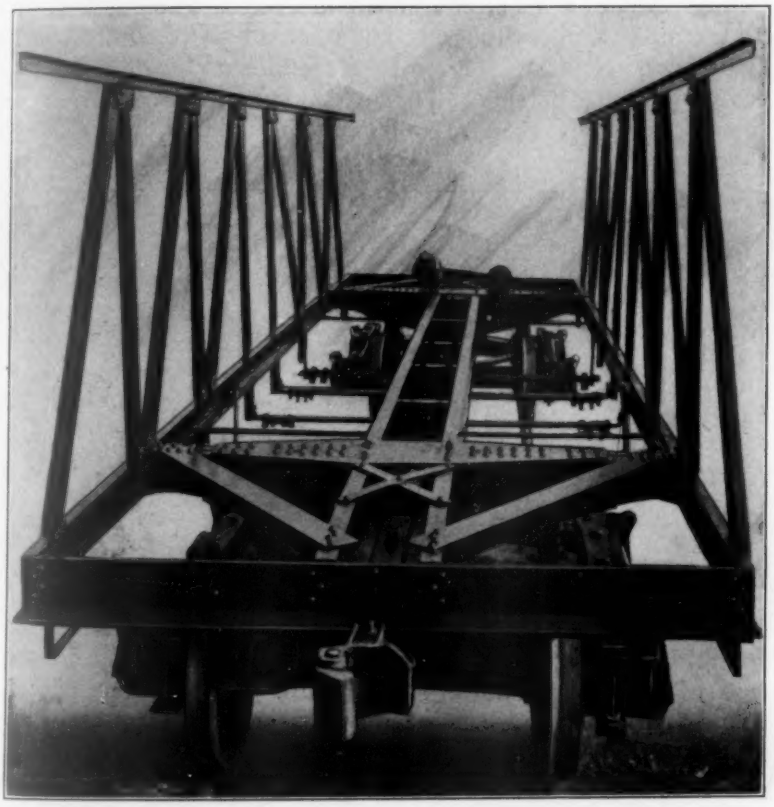
there is a consistency and similarity in all the designs whether hopper or flat-bottomed gondolas or for box or other house cars.

Fig. 14 represents a complete steel-frame box car, and the only way to identify its construction is by the absence of truss rods under the car and its clear, open appearance facilitating inspection and examination. This car is of the American Railway Association dimensions, viz.: 36 feet long by 8 feet 6 inches wide by 8 feet high (inside measurement).

Fig. 15 is another complete steel-frame for a box car, one of my later designs, and is somewhat more complete than Figs. 12 and 13 in showing the steel girths in sides and ends. These assist materially in holding the ends of the car to resist the shock of shifting loads. The corner and end intermediate posts are securely riveted top and bottom and with an inside end

wooden lining 1¾ inches thick, making an end construction that cannot be approached in wood construction. If photographs were available I could also show a new design of furniture car 40 feet long, 9 feet wide, and 10 feet high in which the side doors are not directly opposite but are each offset 27 inches from

FIG. 8.



the centre line. This is to facilitate loading of automobiles and other vehicles. It was somewhat of a problem to the designer, as it called for unsymmetrical side framing and a diagonal connection in the underframing between door posts.

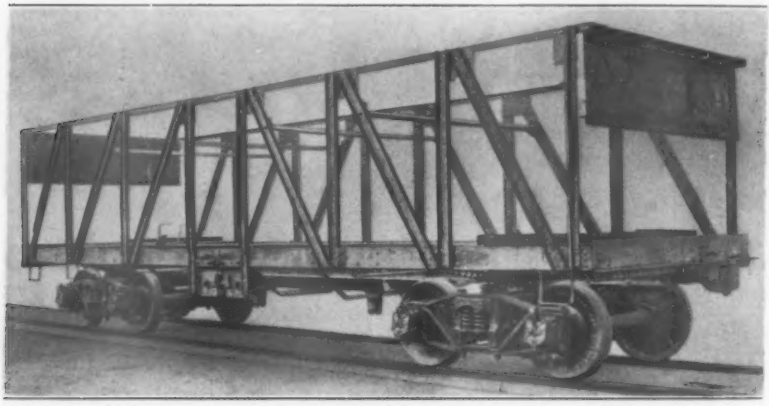
Fig. 16 shows a completed box car, and there are over 6000 of these in service on the C. R. I. & P. and St. L. & S. F.

These cars are 40 feet long inside by 8 feet 6 inches by 8 feet, and as the four feet of extra length goes in between the bolsters the car is not quite as strong laterally as those of the standard length of 36 feet made up of similar sections.

The N. & W. steel-frame box car was first described in the May, 1902, issue of the *American Engineer and Railroad Journal* and also in other papers.

Fig. 17 shows the steel frame, and Fig. 18 a complete stock car which is an interesting example of this type of construction. The wooden slats are secured to the inside of the steel frame, leaving the latter outside and exposed.

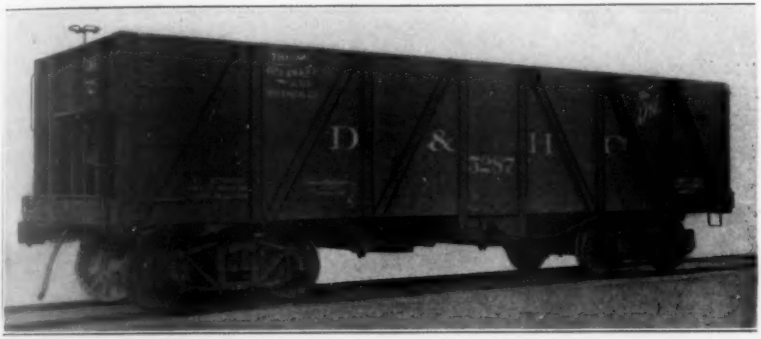
FIG. 9.



A number of designers have used steel underframes for freight cars, placing thereon a wood superstructure. In the case of house cars, however, there are many reasons why a complete steel frame is superior to the above arrangement. Any steel frame is designed to work within small limits of deflection, while the wood structure cannot be so limited, so that the two do not combine well. The requirements of modern train service are better met by steel framing as it is almost impossible to so frame an end for a wooden car that it will successfully stand the shocks in switching and road service. Steel framing also resists bulging of the sides as the tension members are given a bowstring effect by the loading. Steel-frame cars do not sag, sway, or work so as to require the constant tightening up, renail-

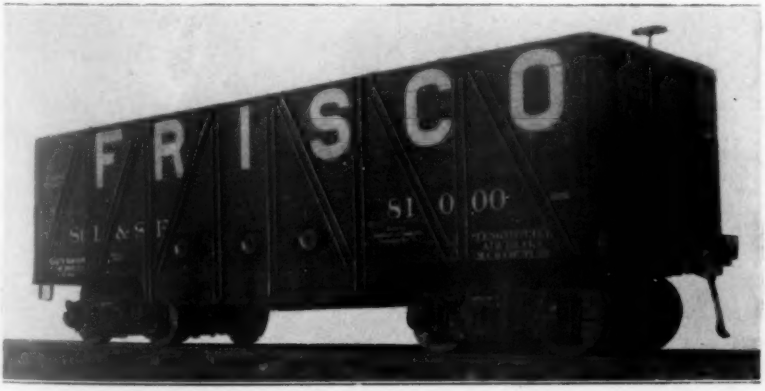
ing, etc., as is necessary on wooden cars. It is now very difficult to find lumber at all suitable for car framing and the prices have equalized so that steel can be used for framing at about

FIG. 10.




equal or better cost than wood. As to whether we should go further than that in the use of steel is a question to be decided by local conditions, service, etc. Lumber is still available for

FIG. 11.



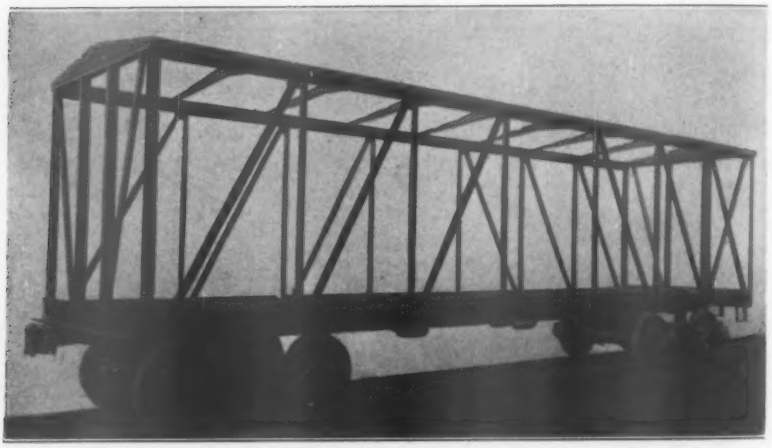

flooring, lining, and covering, and probably will be for some years.

Considerations of weight and strength are of much interest in car designing and especially so in introducing steel wholly or in part in place of wood. Composite construction particularly

favors economy of weight in open cars, giving high percentages of revenue load with low dead weight and the advantages of strength and durability. In steel-frame house cars, however, these percentages of revenue load are necessarily lower as the proportion of wood is higher than in open cars, this for roofing, lining, and sheathing, and the nailing strips for securing them. The well-designed steel-frame box car need not weigh more than a well-designed wooden car and be a better, stronger, and longer-lived car.

The economical application of wood for liners, nailing strips, and fillers is the more difficult part of the design of steel-framed

FIG. 12.

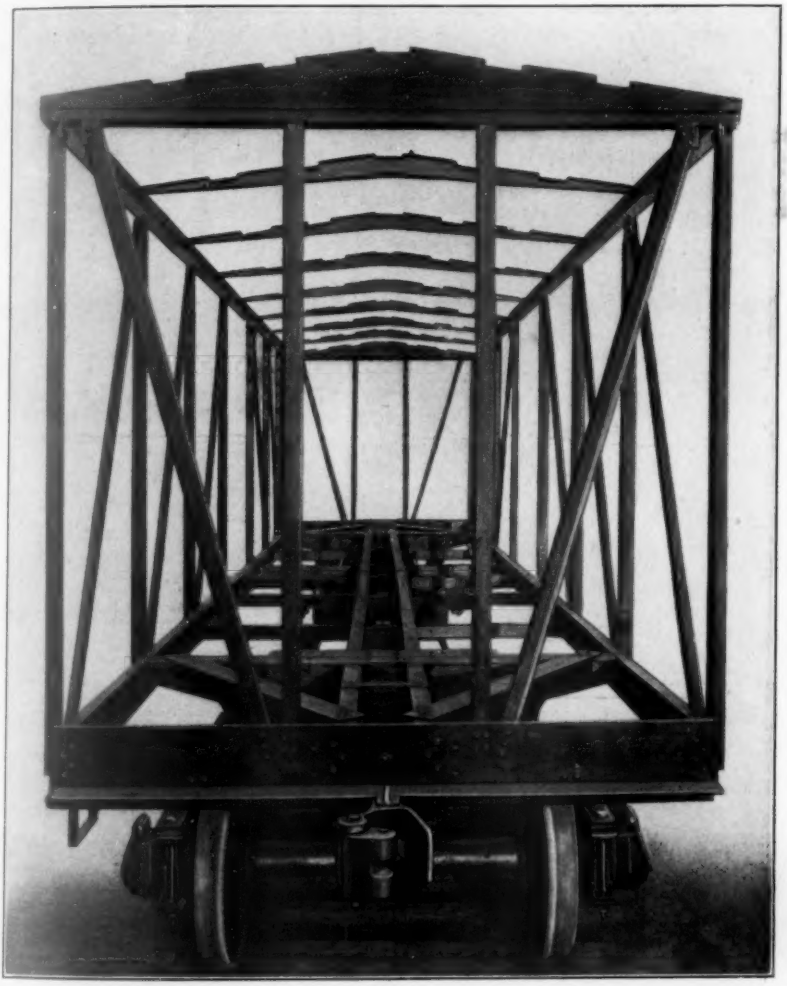


house cars in order to keep the weight down and still offer an adequate fastening surface to which to nail sheathing and lining.

Extensive use of cars of these types of construction has developed considerable information of interest. The cost of repairs of freight cars is not generally divided on railroads into sufficient detail to show the comparative costs for wooden and for steel or composite cars, but such information as we have is greatly in favor of the steel-framed cars. In heavy repairs of wooden cars the cost may be divided into from two-thirds to three-quarters for material and from one-quarter to one-third for labor. When steel is used for framing the proportions are reversed, the larger part for labor and the lesser for material.

In other words, the steel is again usable even though more or less damaged. Shocks which would break wooden members

FIG. 13.



so as to require their replacement would in most cases merely bend or distort a steel one, which may be readily straightened and returned to service. A badly wrecked steel-frame car

looks rather discouraging to one not accustomed to handle such matters, but experience has shown this not to be as bad as it seems. Hand methods have been found most available in handling work of this character, as machinery is of little avail, except in manufacture.

Freight cars get very rough usage and have to stand severe shocks, and ofttimes these are cornering or diagonal which at the time may not break the wooden car but result in its springing back and concealing the damage.

The steel-frame car under these conditions will sometimes yield and stay bent laterally and act as a tell-tale of unfair usage. There is a considerable question as to how far to go in providing

FIG. 14.

lateral strength and stiffening in a car frame. If we consider the strength required for the vertical stresses of loading and impact, we naturally get a proportion of lateral stiffness from the flanges of the channels or other sections used for sills. The crossbearers, bolsters, and fastening of the floor serves to bind the bottom framing so as to give considerable lateral strength. There has been some criticism as to lateral weakness of some steel-frame box cars which are amply strong for carrying their load in normal operation, but will not stand severe cornering shocks without distortion, which occurs between the bolsters. It has been found that in most cases these distorted cars can be jacked back to straight lines without the necessity for cutting them apart, and in view of the cheapness of this class of repair

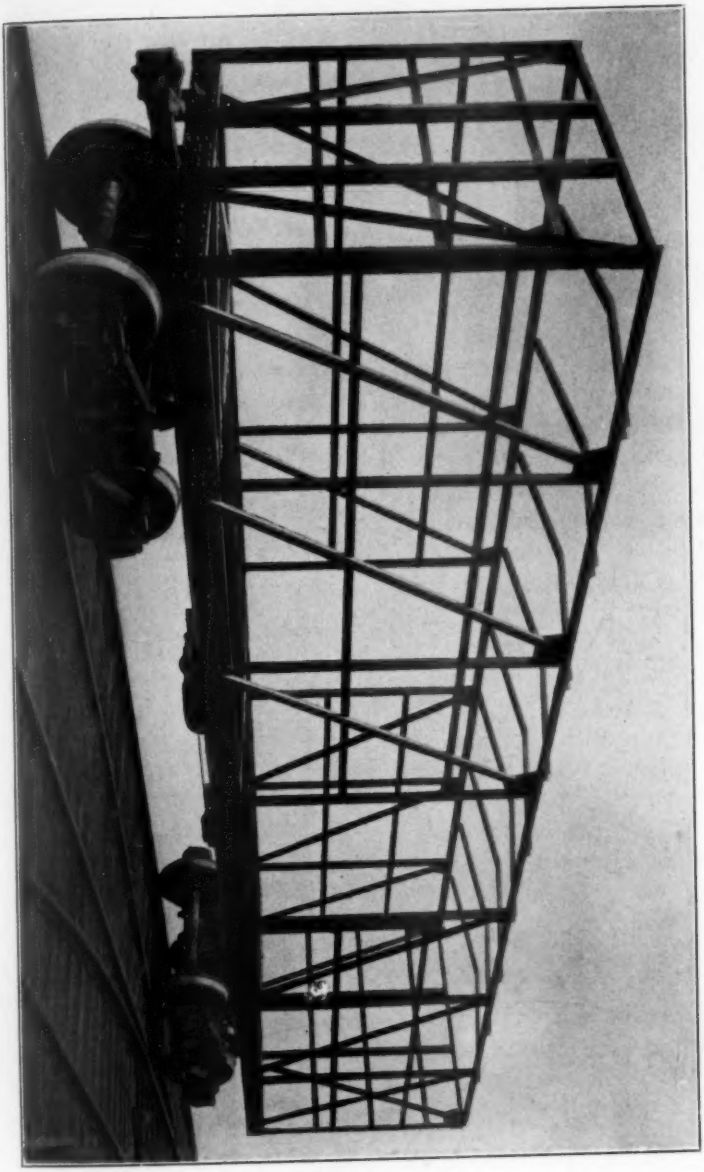


Fig. 15.

it would seem to indicate a desirable economy in the original construction rather than a justification for an additional expenditure for stiffening the frame.

For instance, if these cars are built with a steel side frame and with two-channel centre sills not cover-plated but spacer-bolted and riveted to bolsters, crossbearers, and end plates, if the centre sills by calculation show sufficient strength for carrying their proportion of load, a cover plate would only give an advantage of a certain amount of lateral stiffness. Such a cover-plate would cost say $12 per car, and if we are to build 1000 cars it amounts to $12,000 for a partial insurance against lateral distortion, as it would not be a complete one.

If we should have a dozen distortions a year, and that would be a large proportion for 1000 cars, they could be repaired for a hundred dollars or so. We can afford to do this each year for the life of the 1000 cars and still save a large proportion of the cost of the cover-plating. During the consideration of a certain design it was proposed to splice the sills at the bolsters as this was thought to favor repairs in the case of end damage. It was found that it would cost $2 more per car than if the sills were run through solid to the ends. On 1000 cars this would cost $2,000 and the number of these cars receiving end damage, the repair of which would be facilitated by a splice in the sills, would be so small as to be insignificant and the expenditure almost a total loss.

It is our conviction, therefore, that simple, direct methods of design, looking towards such strength as may be required for normal operation, with such reserve as may be necessary for waste, wear, and corrosion to cover average life will give best economic results, and to provide for more than that, adds unnecessary weight and cost for which there is not adequate return.

The question may be raised that if steel is such a good thing for the frame of a car why not cut out the wood altogether and have a complete steel car. This is undoubtedly true in regard to some classes of cars and in some localities. Results so far obtained with all-steel box cars are not favorable. They are excessively hot in hot weather and to an extent that will damage some classes of lading, and as box cars are required to carry all classes of commodities, this feature is prohibitive of all-steel

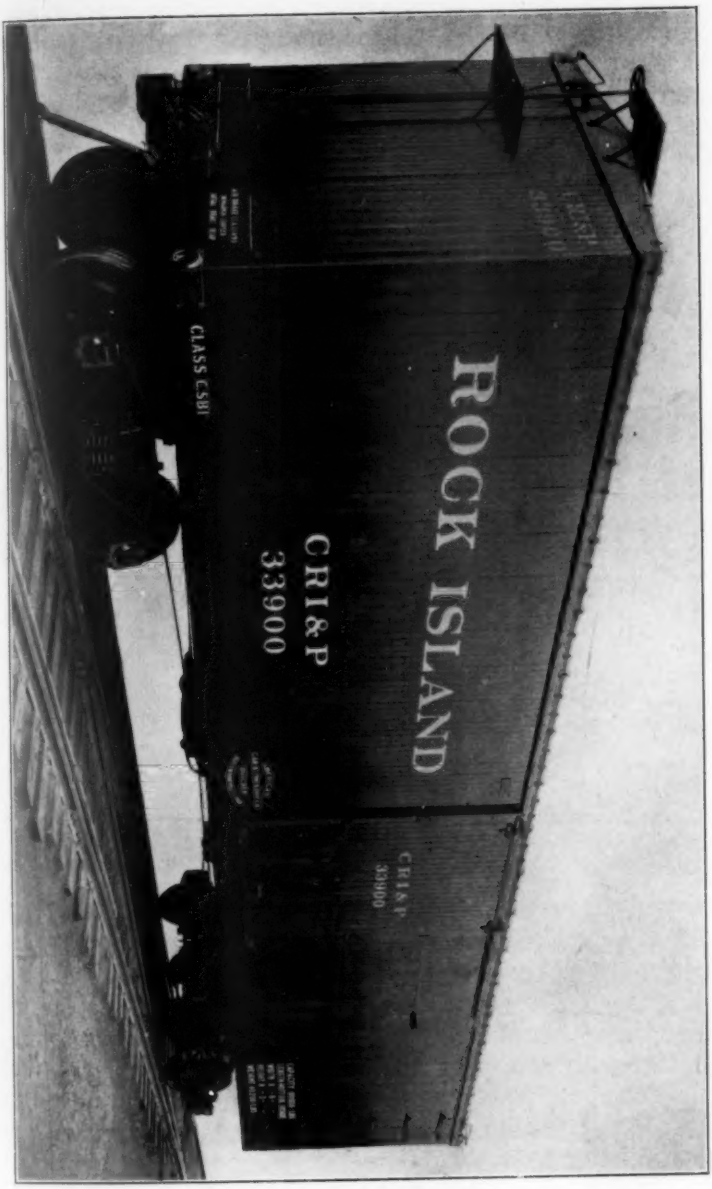
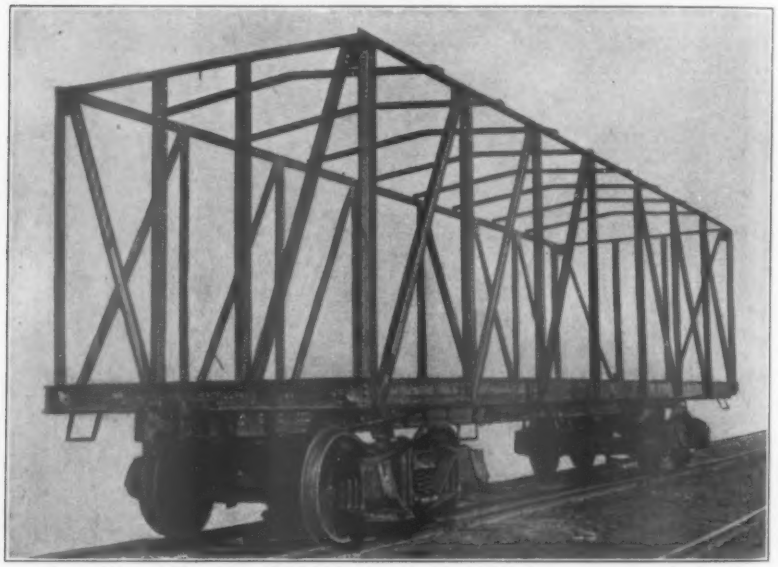



FIG. 16.

box cars. In cold weather, or when exposed to great changes of temperature, steel cars will condense the atmospheric moisture and cause the condition called "sweat," and this is also prohibitive on account of many classes of lading, which require clean, dry storage when in transit.

For open cars to which the above objections do not apply, the choice of all-steel or composite construction is governed by service and cost conditions. On roads serving industries where

FIG. 17.

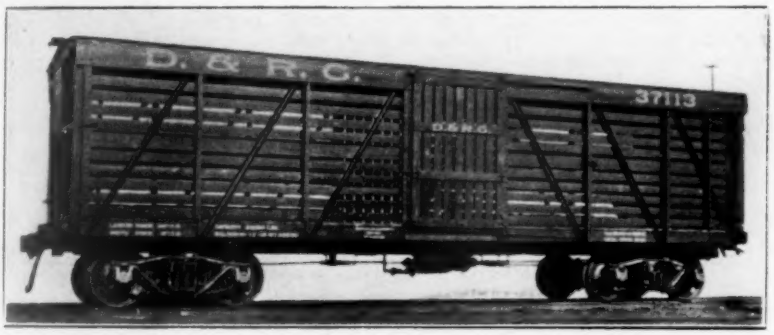


there is a large proportion of hot lading, as at rolling mills, smelters, etc., when hot materials are frequently loaded direct into cars, all-steel construction is the better proposition. If such conditions do not prevail, then the comparative cost of all-steel and of composite construction together with consideration of repair facilities may be taken into consideration. It has been amply proven that the questions of weight, percentage of revenue load, cost and facility of repairs, durability, and general reliability can be as strongly claimed for composite construction as for all-steel when both have an equal weight of other factors affecting the question. Many designs of all-steel cars have given

magnificent results, and it is not the intention to detract from their merits. At the same time, having been concerned in the development of the composite construction of freight cars that has grown to considerable proportions, the writer has welcomed this opportunity to present for your consideration some of the features of a very interesting development in railway transportation.

Neither the writer nor any one connected with the N. & W. Ry. made any attempt toward patenting the car designs made by him. It is now several years since they have been public property, and they have been very extensively copied by railroads, car companies, and others, the only returns to the writer being a

FIG. 18.




sense of satisfaction and pride of achievement as a successful designer. Papers describing and illustrating these theories of car construction have been contributed to the railway press or to railway clubs, some of these being as follows: Paper read before the Richmond Railway Club, May 8, 1902; Paper in the *American Engineer and Railroad Journal*, Jan., 1903; Paper read before the Western Railway Club, March 15, 1904; Address to students of Purdue University, April 11, 1905.

It is now nearly ten years since the first developments on the lines described above, and while the freight equipment of the country is still largely of wooden construction, the new cars that are being built are mainly with steel used to a very considerable extent in their framing and the tendency is very considerably on the lines which have been indicated of composite construction.

## IRON IN THE BIRMINGHAM DISTRICT.

REPORT ON ORES, FUELS, AND FLUXES.

The United States Geological Survey has just published as its Bulletin 400 a report on the iron ores, fuels, and fluxes of the Birmingham district, Alabama, by E. F. Burchard, Charles Butts, and E. C. Eckel. The term "Birmingham district" denotes the region whose mining industries are tributary to the blast-furnaces grouped around Birmingham—a region comprising a northeast-southeast belt about 10 miles wide and 75 miles long. The report sketches the general geology of this region, discusses the origin and geologic relations of the iron ores, and describes the numerous deposits. The methods of mining and prospecting are also described. In the section on fuels the available quantity and the composition of the coking coals are discussed, as well as the methods of coking and the character of the coke. The limestones and dolomites that are used as fluxes are also briefly considered.

IRON ENOUGH TO LAST A CENTURY.

Since 1894 Alabama has held third place among the iron-mining States and in 1909 produced more than 4,000,000 long tons of ore. Of this total product the Birmingham district produced over 3,000,000 tons. Practically all this ore is made into pig-iron in the Birmingham district, in which there are 29 coke furnaces. The ores, broadly considered, are of two kinds—red or Clinton ore and brown ore. Seven-eighths of the ore mined in the district is red ore. It is estimated that 500,000,000 tons of the red ore are available for mining by present methods—a supply that will last more than a hundred years.

VALUABLE MAPS.

The report contains 200 pages of text, a large geologic map of the district, a map showing its economic features—deposits of iron ore, coal, and limestone, the mines, quarries, railroads, blast-furnaces, and steel plants—and other maps and illustrations, and can be obtained without charge by applying to the Director of the Survey at Washington.

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## MANGANESE DEPOSITS OF THE UNITED STATES.

PRELIMINARY REPORT BY GEOLOGICAL SURVEY.

A detailed report on the manganese deposits of the United States, by E. C. Harder, of the United States Geological Survey, is in preparation for publication, and a brief digest of the main portions of that report appears in the Survey's Bulletin 380–E, just published as an advance chapter from "Contributions to Economic Geology, 1908, Part 1." The preliminary paper contains notes on the sources and uses of manganese and the present status of the industry, together with brief descriptions of the principal localities where the ores are obtained.

SOURCES OF MANGANESE.

Manganese is in this country derived from four classes of materials.

Manganese ores comprise the oxides and the carbonate of manganese. The most abundant deposits are in the Appalachian and Piedmont regions, in the southern part of the Mississippi Valley, and on the Pacific coast.

Manganiferous iron ores consist of a mixture of any oxide or the carbonate of iron with any oxide or the carbonate of manganese. They occur chiefly in the New England, Appalachian, and Lake Superior regions.

Manganiferous silver ores consist of a mixture of manganese and iron oxides with small amounts of silver sulphide and lead carbonate and in some places of gold. They are found in the Rocky Mountain and Great Basin regions.

Manganiferous zinc residuum is obtained from zinc volatilizing and oxidizing furnaces using zinc ores from the Franklin Furnace district, in New Jersey.

OCCURRENCE OF THE ORES.

The ores of one or another of these various classes occur in many parts of the country, but the chief producing States at present are Virginia, Tennessee, South Carolina, and California. In Virginia the principal deposits are in the James River valley near Lynchburg, on the west slope of the Blue Ridge from Port Royal to Roanoke, and in several belts in the New River region. The Tennessee deposits are the southward continuation of those of the Appalachian Valley in Virginia, and occur mainly in Cocke, Unicoi, and Johnson counties. In South Carolina the most important deposits are near McCormick, in Abbeville County. The principal California deposits are near Livermore, in Alameda and Santa Clara counties.

USES OF MANGANESE.

The uses of manganese in the industries are metallurgical, in the manufacture of alloys and in copper and silver reduction, and chemical, as an oxidizer and a coloring agent. The principal alloys, spiegeleisen and ferromanganese, are used in various ways in the steel industry, the addition of small quantities of manganese giving to steel hardness, ductility, and strength. Manganese bronze is used for steamboat propellers and other alloys are used for coins, statuary, and ornamental purposes.

THE MANGANESE INDUSTRY.

Little manganese ore is now mined in the United States, the total in 1907 being only 5604 tons, against 209,032 tons imported, chiefly from India, Brazil, Cuba, and the East Indies. The average grade of the domestic ores is much lower than that of the imported ores and they require considerable treatment to prepare them for the market.

Virginia is by far the largest producer of manganese, furnishing more than four-fifths of the 1907 output and more than 55 per cent. of the total production in the United States to January 1, 1908—396,623 tons.

## VANADIUM.

UNDEVELOPED DEPOSITS IN THE UNITED STATES.

Deposits of ores of vanadium, one of the rare metals, occur at several places in the western part of the United States.

VANADIUM A STEEL TOUGHENER.

The most important use of vanadium so far discovered is as an alloy of steel, to which it adds remarkable toughness. Its effect in steel is said to be due to its removal of oxygen and nitrogen, to its union in a solid solution with the iron, and to its formation of carbides that increase the strength of the steel. It is said that steel treated with vanadium has great resistance to shock and to fatigue caused by constant bending, that it makes much better saws and springs, and that high-carbon vanadium steels also make much better tools, such as cutters and riveting dies. About 0.1 per cent. of vanadium is used for deoxidizing and denitrogenizing steel, and about 0.25 per cent. of vanadium is left in the steel itself. It is ordinarily used with chromium or manganese, or both, to which nickel may also be added.

OTHER USES OF VANADIUM.

Vanadium has also been used in cast-iron with good effect, and experiments with brass and bronze show that it may be used with advantage in these alloys.

Vanadium salts are said to be favorable to the growth of plants; vanadyl phosphate acts physiologically like potassium permanganate; from vanadates and tannic acid a waterproof black ink is made; vanadium salts are used in coloring glass; metavanadic acid has been used as a substitute for gold bronze in paint; vanadium chloride is used as a mordant in printing fabrics, and the trioxide as a mordant in dyeing. Vanadium compounds are used for several purposes in chemistry.

# ELECTRICAL SECTION

*(Stated meeting, held Thursday, February 17, 1910.)*

## AUTOMATIC SIGNALS FOR ELECTRIC RAILWAYS.

BY

**CARL P. NACHOD, E.E.,**

General Manager, Nachod Signal Company, Philadelphia.

[This paper is a brief review of the general field of Electric Railway Signalling together with a fuller description of a particular type of contact system.]

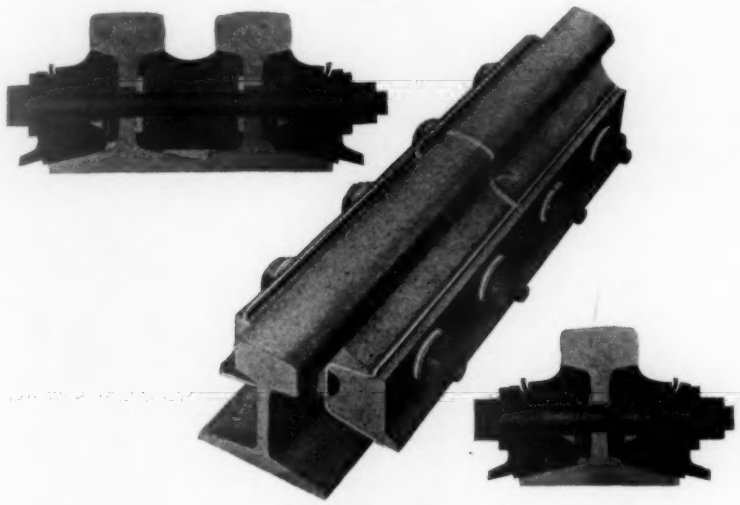
AUTOMATIC Electric Railway Signalling may be divided into two kinds as regards control of the signals, namely, the track circuit, and the contact systems.

In the former, as first used on the steam roads and developed by them, the rails are separated by insulated joints into blocks of not more than a mile long. Fig. 1 shows such a joint, metallic contact between the abutting rail ends and fish-plate being prevented by fibrous insulation, which is used also as a bushing for the connecting bolts. The wood ties and ballast form the only insulation between the two rails themselves. A low voltage battery—two gravity cells in multiple—is connected across the track at one end of the block, and a relay, consisting of an electro-magnet having a contact making armature, at the other end. Fig. 2 shows the track circuit in its simplest form. When the block is clear there is thus a current continuously flowing from the battery up one rail, through the relay magnet, down the other rail, back to the battery. The relay magnet, being continuously excited, attracts its armature, which is arranged to hold closed a pair of contacts in an independent local circuit. Current flowing in this circuit when these contacts are closed keeps the signal mechanism indicating clear. When a train, or even a pair of wheels enters the insulated block, the current is shunted from the relay, through the wheels, by virtue of their relatively low resistance, causing the armature to drop, opening the local

circuit, and permitting the semaphore or other indicating mechanism to go to danger by gravity. This dropping of the armature might be occasioned as well by the failure of the circuit at any point, or in any manner, such as by the breaking of the rail. In addition to this the track switches may be interlocked so that, if misplaced, they will short circuit the rails in the same manner as by a train, and indicate danger. The conditions of safety are therefore very well met according to this system.

The amount of energy delivered to the block for signalling is surprisingly small, considering the importance of the work done

FIG. 1.



Insulated rail joint.

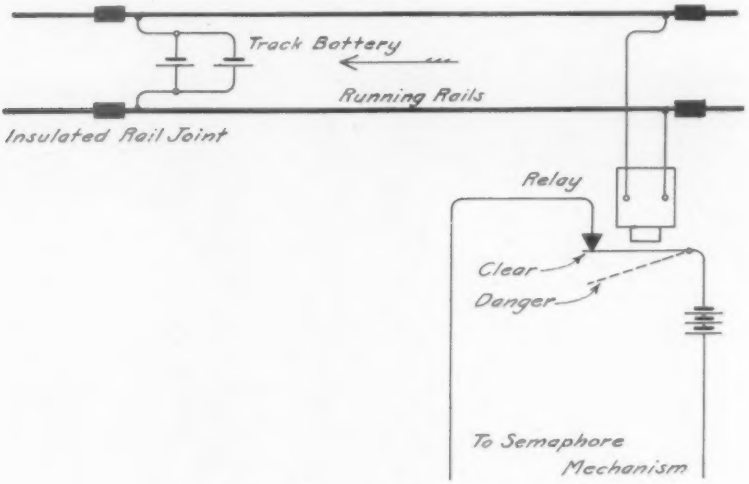
and the many human lives to be safeguarded, being rarely more than half a watt. At least one-half of this is wasted, due to leakage from rail to rail, and the relay operates on less than one-fourth of a watt. A type of d.c. relay is illustrated in Fig. 3. It is a delicate instrument, having the contacts sealed in glass to protect them from atmospheric influence.

The continuous track circuit indicates by the *presence* of a train; and such indication will remain so long as the train is in the block, regardless of whether it is moving, or which way it is moving. It has been used on steam roads and for other similar purposes since 1857.

Against the advantages enumerated above of such a track-circuit system, the objections are the difficulty of maintaining the insulation between the rails in wet weather, and especially if the roadway is impregnated with brine drippings from refrigerator cars; the influence of foreign or stray currents on the delicate signal current, due particularly to the earth return of Electric Railways; and the maintenance of the batteries.

On Electric Railways the track-circuit system may not be applied in so ideally simple a manner as indicated above, since the relatively enormous return propulsion current through the

FIG. 2.



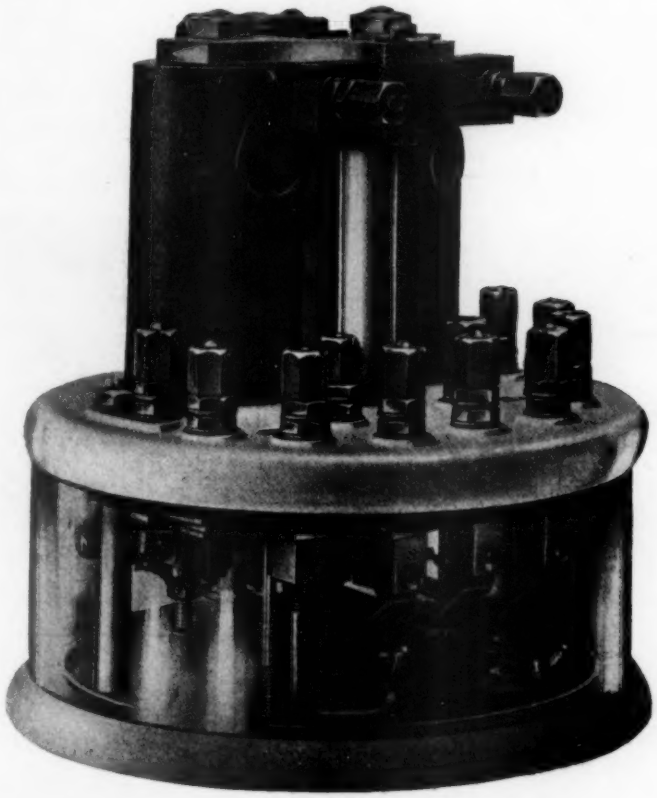

Essential diagram of track circuit.

rails would conflict with the signalling current. Fortunately, however, the essential principle can be retained by means of alternating current for signalling, which by its inductive properties may be caused to act selectively upon suitable signal apparatus.

Fig. 4 shows a system suitable for subway or elevated roads with short blocks. Only one rail can be used for the traction current return, the other being insulated from the earth and divided into blocks by insulated joints as above described, this rail being reserved for signalling. Protection against a broken rail is not given with a single rail system. The track is energized from

the a.c. signal mains at about 7 volts, 25 cycles through the transformer connected at one end of the block. The relay is connected at the other end; and a non-inductive resistance in series with it, and a reactance coil shunting it, limit the amount of direct current passing through it, due to the voltage

FIG. 3.



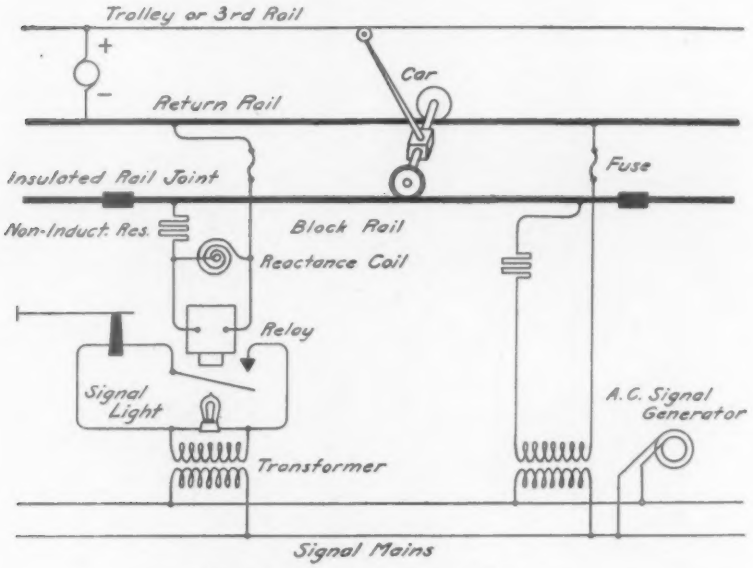
Type of direct-current track relay.

drop through the return rail. The relay shown in Fig. 5 acts on the induction principle, and consists of an aluminum vane or disk pivoted between the poles of an electro-magnet, and carrying contacts, a motion of the vane being caused by alternating current only.

Fig. 6 shows a system for longer blocks, where both rails

are used for the return of the propulsion current. A broken rail will give a danger indication with this system. The feature of interest is the reactance bond, rendering the adjacent blocks electrically continuous for the traction current, but separating them for signalling. The traction current flowing equally in each rail enters the bond at its opposite ends, leaving by the middle, and enters the bond on the next block at the middle, leaving at the ends and continues through the block. The magnetizing

FIG. 4.




Single-rail alternating-current signal system.

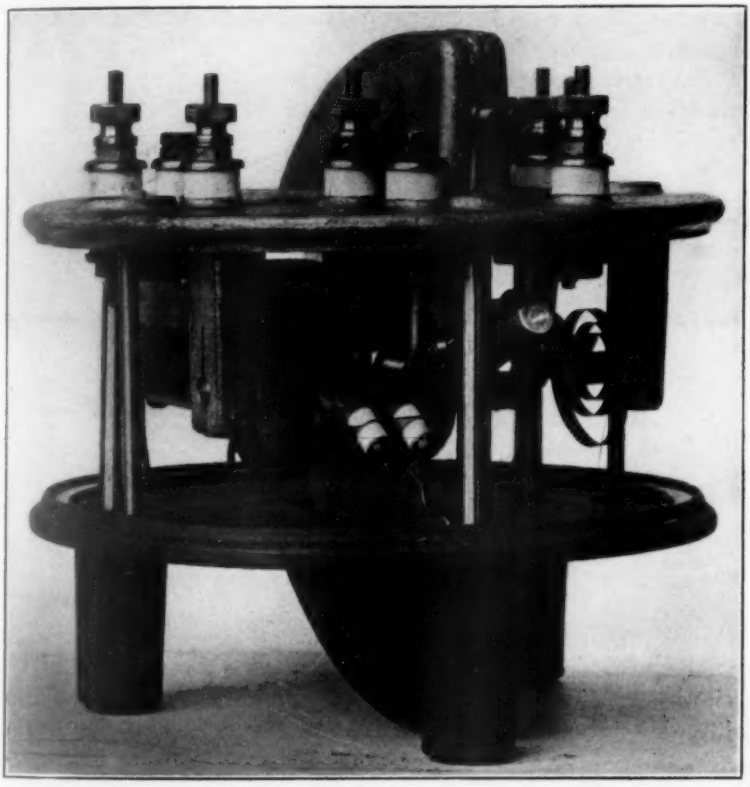
effect on the iron of the bond will be nil since the currents are equal and opposite. The bond, however, opposes a high reactance to the alternating signal current from rail to rail.*

In contact systems, on the other hand, the display of the signal is dependent on the car or train having passed a given point where a contact device is located. In general, while these are hardly as safe as the track circuit systems, they are very much

* For articles on track circuit systems see: Electrical World & Engineer, Aug. 23, 1902, p. 272; The Signal Engineer, July 1909. p. 37; Electric Journal, July, Aug., Sept., Oct., 1907.

less expensive. The contacts are arranged to be made either by the trolley wheel overhead, by a separate contact shoe, by the car wheel itself, or by a short insulated track section. In the first method it is out of the way of malicious interference, or of that by traffic, such as teams. Overhead contact systems are of two

FIG. 5.



Type of alternating-current track relay.

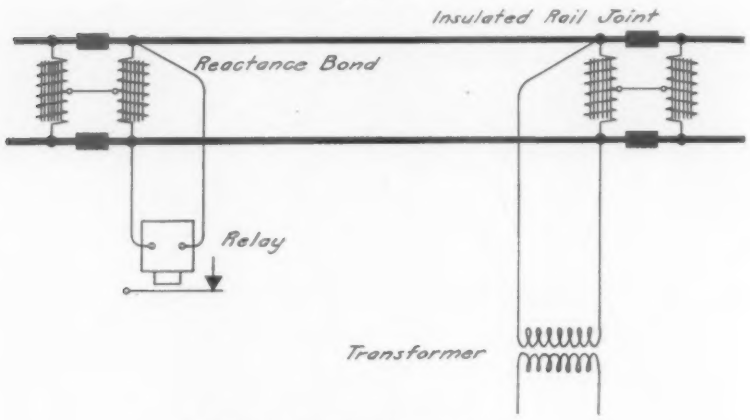
kinds: those containing moving parts, and those without them. In the former case a trigger or pendulum hanging down over the trolley wire, is struck by the wheel in one direction or the other, making either of two contacts so as to set or clear the signal. The moving parts in these, which must be complicated by an inertia device or a dash pot to prolong the excessively short

contact, are inaccessible for inspection and maintenance, and the blow produced by the wheel at high speeds is serious, tending to throw the wheel from the wire or destroy the trigger.

Contact switches without moving parts are usually of the shunt type, the metallic wheel bridging two strips and diverting a current through the magnet to be operated. In the series type the entire car current passes through the signal magnet, in consequence of which, if the car should drift under the switch with the controller off, the signal would not be operated.

They may be arranged as non-directional, that is, so as to cause the same impulse of current for actuating the signals, irre-

FIG. 6.




Double-rail alternating-current signal system.

spective of which direction the car is moving; or directional, one strip being divided electrically and connected in combination with reversing magnets, so as to set or clear the signals according to the direction of the car, a self-explanatory scheme of connections being shown in Fig. 7.

Signal indications may be given by position or color. For day both are in general use, but by night color only in the form of light has attained any wide-spread recognition. Red is always employed for danger or stop, but usage is not uniform for the other colors, the commonest perhaps being green for caution and white for clear. There is a present tendency toward white or yellow for caution, and green for clear.

The semaphore is the most easily discernible form of signal aspect, and consists of an arm which at danger is at a horizontal position, as though it were a bar across the track to prevent the passage of the train. When clear, the arm is moved to a vertical position, either up or down; the former, called upper quadrant signalling, has the point of safety that accumulations of snow or ice increase the tendency of the arm to fall to danger. The intermediate (45 degree) position is also frequently used as a cautionary signal. The semaphore is usually arranged to fall to danger by gravity and held to clear by the current in the system. The driving power is compressed air controlled through

FIG. 7.

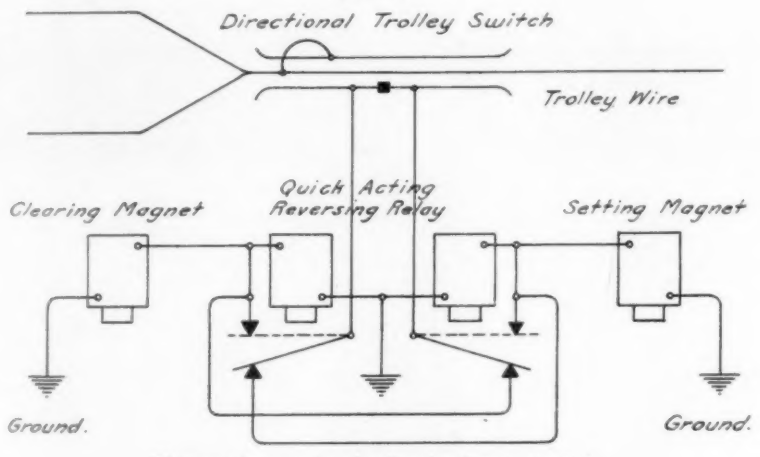


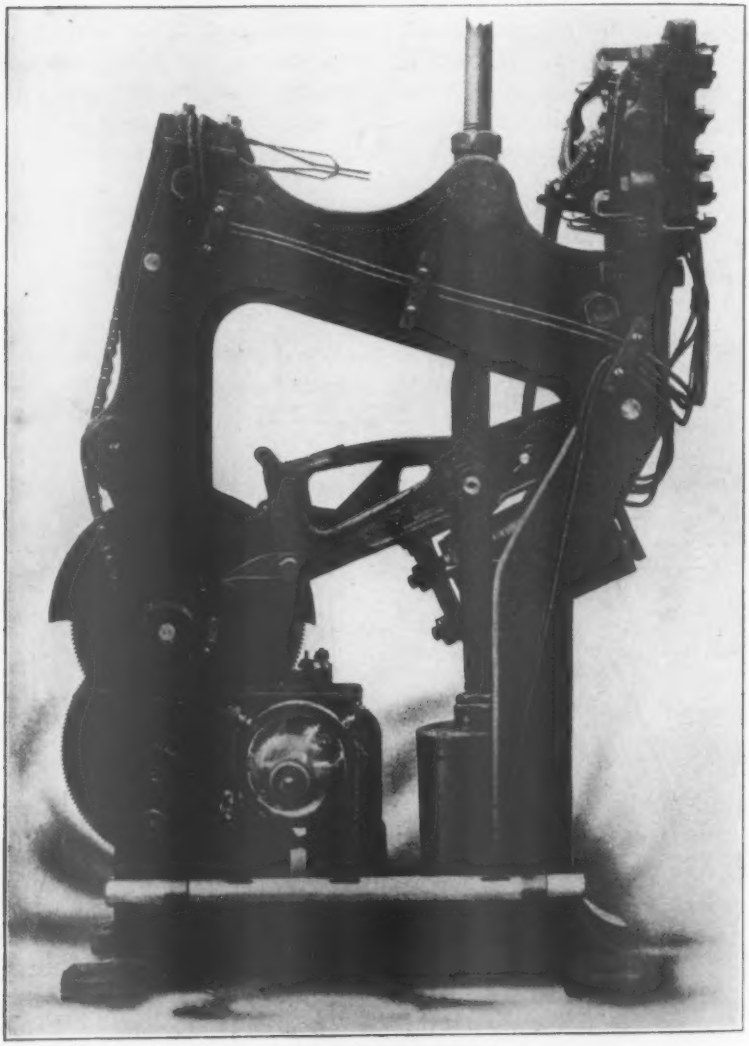

Diagram of connections for directional contact switch.

electro-magnetic valves, or electricity, applied either through a suitably geared motor, or by the direct pull of a solenoid.

The objection to the semaphore is that on account of its being exposed to the elements, the effect of rust, snow and ice is to require considerable excess power to operate it, an elaborate installation thereby becoming necessary.

Fig. 8 shows a motor-driven semaphore-mechanism located at the base of the semaphore pole, and Fig. 9 a simpler mechanism placed at the top of the pole. They consist essentially of a motor, gearing, clutch, switches and dash pot. The motor is of high efficiency, battery driven, consuming about 20 watts. The commutator is glass-enclosed.

FIG. 8.



Semaphore mechanism at base of pole.

The enclosed disk indication, in which a light opaque disk appears or is withdrawn from an opening covered with clear glass, though inferior to the semaphore as regards visibility,

makes a reliable day indication. On account of its being protected from adverse weather conditions the construction may be simple and the power to operate it quite small. Where electric light is used as illuminant, the heat from it is sufficient to prevent any obscuration of signals by snow on the cover glass.

Signals are arranged so that when no car or train is on the block, they will be either at clear, when they are known as normal

FIG. 9.

Semaphore mechanism at top of pole.

clear systems, or at danger, as normal danger systems. Both systems have their advocates, and there does not seem to be a marked preponderance in the use of one over the other.

The contact system to be further described is intended for electric railways, wholly or partly single track, where cars run both ways on the single track parts. In track circuit systems in general the signal is located at the insulated track section, which is the entrance of the block, and the engineman of the train entering the block assumes that the signal he leaves behind will drop

to danger; nor does he look behind him to see that it has, before proceeding. In the class of signals to be described, however, it is desirable that the signal indication should be set sufficiently in advance of the contact device for setting, that the motorman may see the effect of his passing the device before he enters the block. In such a case a three-indication signal is preferable, having a neutral indication which can be changed to proceed or stop by the passage of cars, the neutral indication meaning that a motorman may pass the contact device, the block being presumably clear. In this manner the motorman protects himself with signals before passing the indication.

When the motorman about to enter the section of single track perceives that the signals are neutral, it indicates that there is no car on the block of single track, provided the signal system is operative. As his car passes under the contact switch, the trolley wheel causes an impulse of current to flow through the relay, which has the effect of setting permissive signals in front of him and danger signals at the other end of the block simultaneously, the circuit of the permissive signals being completed through that of the danger signals. The former is therefore an indication that the latter are displayed. Night and day signals are given at the same time in each box by a light and an opaque disk of the same color; for a light alone, under certain conditions of direct sunshine and low voltage, is very unreliable as a day indication; but the conditions that are against a light indication are all the more favorable for the disk indication, and vice versa.

The motorman having seen that the effect of his car running under the contact switch has been to set the signals, and that he has thereby protected himself, proceeds past the signal box into the block. The red signal, meanwhile displayed at the other end of the block, would prevent a car which might have come up, from entering against him. When his car arrives at the end of the block, it runs under the contact switch, causing the signals to return to normal or neutral indication; after which the car held up by the red signal may now proceed into the block, setting the signals similarly but oppositely, and passing out will clear them.

This signal, however, is used for what is known as permissive, as opposed to absolute block signalling. A number of cars are admitted into the block from one end, and the signals

held permissive at that end, and danger or stop at the other, so long as a car occupies the block. In the absolute block system, on the other hand, when a train occupies the block a danger or stop signal is displayed at both ends of the block.

To illustrate, suppose a car has entered the block and set the signals; and before it leaves, a following car arrives at the end of the block showing white. The motorman will understand by this that there is at least one car ahead of him going in the same direction, and that he may enter the block under control. As his car runs under the contact switch he observes the signal box, and notices the flash or blink of the white light that his car causes, which is an indication that his car is counted in or registered in the signal relay; and so on for a number of cars following each other, each receiving its signal that there are other cars ahead of it, and that it has counted in. When the first car arrives at the end of the block, in running under the contact switch it causes a blink of the light, but the signals are still set as before. They so remain until the last car clears them, leaving the block ready for cars in either direction.

The above is the normal operation, but if a car should enter the block from one end and back out by the other track at the same end, using the single track merely as a Y or cross-over, the signals will be cleared when the car leaves the block. This makes a very flexible operation, as in the complicated case where a number of cars enter the block from one end, and are continuously entering and leaving, some leaving by one end and some by the other, but the signals protect all the cars in the block, and are cleared only when they all leave it.

When the red signal is displayed, then the entering switch at that end of the block is "dead" or cut out of operation, and indications may not be changed by a car running against the red signal. This is of advantage in two ways. Should a motorman intentionally violate the red indication and enter despite it, and a head-on collision result thereby, the signals will not have been changed, and the responsibility will be placed upon the offender. A knowledge of the certainty of his detection adds a safety feature to prevent the motorman from attempting to pass the signal set against him. A more frequent use of the lock-out device, as it is called, however, is the case where, two cars approaching the block from opposite ends, one reaches the contact

switch a moment before the other and, obtaining a permissive signal, goes ahead. The motorman of the second car sees the red flash up, but is too near the contact switch to stop before

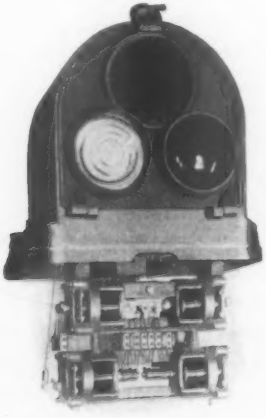
FIG. 10.

Signal box showing white semaphore indication.

FIG. 11.

Signal box with front down, showing semaphore discs, white indicating, and giving access to lamps and fuses.

FIG. 12.



Signal box with oil tank removed, exposing relay. Red semaphore indicating.

passing it. He accordingly brings his car to a stop, and backs out again to wait, but the contact switch being dead, neither passage of his car will affect the signals.

Should two cars run under the contact switches from opposite ends at exactly the same instant, then the permissive signal will not remain set by either car. They will therefore back to the contact switches, and the one reaching it first will hold up the other car. This of course is of very infrequent occurrence.

The signal may also be operated as an absolute block system by leaving the hand clearing switch open, which is equivalent to opening the line wire. For instance, a work train, entering the block to repair the trolley wire, closes the block at both ends by the motorman of the work train leaving the hand clearing switch open, when no permissive signals may then be obtained from either end. In order to leave the signals for normal operation again, he must close the switch when leaving the block.

In case of failure of line voltage, on its resumption the signals reappear indicating the same as before.

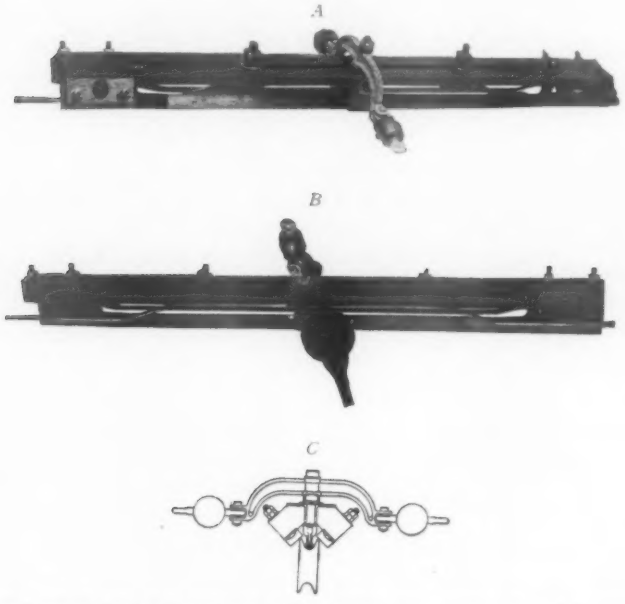
The mechanism of the signal itself may be divided into three parts: (1) the *indicating*, consisting of the lamps, color lenses and opaque color disks; (2) the *intermediate*, which is represented by the relay, which converts the impulses of current caused by the passage of the car into signal indications; (3) the *actuating*, consisting of the overhead trolley contact switches, which by the passage of the car determine the setting and the clearing of the signals.

To describe these in the order of their mention, the signal box, Figs. 10, 11 and 12, is a cast-iron case, the upper part of which is devoted to the indicating mechanism. The front cover is hinged to give access to the lamps, and has three openings: the upper, covered with clear glass through which one or the other of the color disks may be brought to an indicating position; the two lower openings, which have white and red semaphore lenses, respectively, behind which are lamps. The disk that is not indicating is used as a screen for the other lens. The disks are mounted as levers of the first class, counterweighted so as to fall to the indicating position by gravity, motion being communicated to the disks by means of push rods operated from the relay magnets below, the connection being such that the quick motion of the magnet is not transmitted to the color disk, which is thereby relieved of any shock.

The intermediate mechanism consists of the relay, shown in the lower part of Fig. 12, which is designed as an independent

and easily replaceable unit. It consists of a number of iron-clad electro-magnets of the stopped-plunger type, arranged to open and close the switches by sliding contact-rings on which fixed spring-fingers press. The counting means is a magnet-driven ratchet and pawl. The entire relay, including both magnet-coils and switch-contacts, is immersed in oil. This prevents rust, lubricates the moving parts continuously, and lessens

FIG. 13.




Three Views of Trolley Switch.—*A*, trolley switch, from above; *B*, trolley switch, from below, showing trolley wheel running on contact strips; *C*, end view of switch, showing self centring inclined contact strips.

the violence of the magnet action, which otherwise might loosen the parts. It extinguishes the arc at the break, keeps the coils cool, so as to increase the range of operating current, improves the insulation of parts, by decreasing the leakage distance, permits of compact design, and lessens the liability to lightning damage. The connections from the relays to the lamps and incoming leads above are automatically made by spring contacts. Each of the magnet circuits is so designed that a powerful current starts the movement of its plunger, but when the latter is

nearly seated, the current is reduced to a safe value, either by inserting resistance in its circuit, or shunting current around it.

The trolley switch (Fig. 13) consists of a light angle-iron frame supporting at its ends through insulating blocks two flexible inclined contact-strips, the trolley wire being withdrawn during the length of the contact strips, which are formed to receive the wheel without shock. One strip is connected to trolley, the other to ground through the relay. The wheel, being a metallic conductor, bridges them and sets the signal whether the car is taking power or not at the instant of passing the switch.

But one line wire is required for this system, and the installation consists of the hanging of two signal boxes on poles,

FIG. 14.

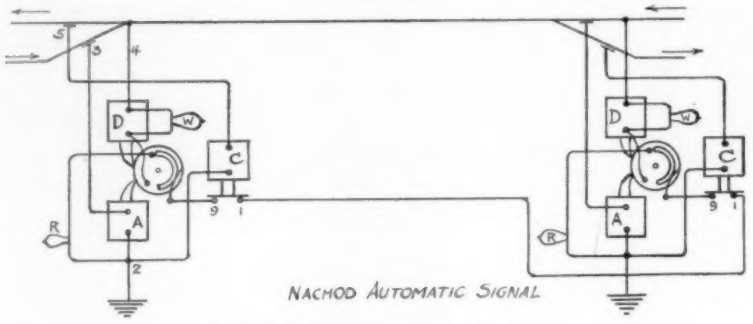



Diagram of operation—contact system.

and four trolley switches in the four branches leading to the single track, with the necessary taps to each.

The electrical operation of the signal is shown in Fig. 14 in which only the parts essential to a comprehension of the scheme are given. The parts are in position for no car on the block, in which case each end of the signal wire is grounded through a red lamp *R*. With no current in the coils, armatures drop. The first entering car sends an impulse of current through magnet *A* in the relay at the entering end, operating a two-way revolving-switch, which transfers that end of the signal wire to trolley through a white light *W* and a magnet *D*. This light and the red one at the other end now burn in series through the signal wire. Successive following cars turn the revolving switch so that the contacts overlap further, but make no change in the

electrical circuit. Each leaving car energizes magnet *C* to break temporarily the signal circuit at 9–1, permitting magnet *D* in the first relay to drop its armature and revolve the switch in the reverse direction. When the same number of impulses have been made on the magnet *C* as on *A*, that is, when all the cars that have entered the block have left it, the signals are cleared and the connections are as shown. The color disks are brought to an indicating position by magnets *D* and one in shunt with *R* not shown. A no-voltage magnet, not shown, is interlocked with magnet *D* in such a manner as to prevent a motion of the armature of the latter should the power fail with cars on the block.

## TIMBER CONSERVATION ON THE PACIFIC COAST.

The Pacific Coast lumber manufacturers have taken the initiative in an important step for the promotion of proper and conservative use of their timber supply. Practically all of the large manufacturers of lumber in the States of Oregon and Washington have entered into an agreement to manufacture odd, as well as even lengths in flooring, finish, and similar planing mill products. Heretofore, it has been customary to manufacture these products in even lengths only. Now, it is proposed to trim the manufactured lumber to lengths of odd numbers as well as even numbers of feet. Under the old system, a considerable portion of the lumber which came to the shaping machine was wasted and this action has been taken in order to save that waste.

Considerable opposition to this innovation has arisen among retailers and consumers. The retailer contends that it is impossible for him to dispose of odd length material because of the common practice in the construction of wooden buildings, claiming that the initial saving of the manufacturer is transferred to the consumer. This is denied, however, because of the proportionally small amount of odd length material which will occur under the new system, and because of the latter day practice of laying subfloors of rough lumber and sheathing on the sides of the house before putting the finishing material in place.

Because of the conservation element which enters into this question, the United States Forest Service has been recommending the adoption of odd lengths for some time past. The Portland office of the Service has recently made an investigation of the actual amount of unnecessary waste incident to the manufacture of even lengths only, and these figures show that under the old system the refuse burner consumed about two per cent. of the total amount of the important forms of planing mill products which are manufactured from Douglas fir and other important forest species, in the States of Oregon and Washington.

When it is considered that about 750,000,000 feet of planing mill products are manufactured annually in the two states mentioned above, this two per cent. assumes important proportions. The Forest Service is authority for the statement that 15,000,000 board feet of high priced lumber can be saved annually in Oregon and Washington by the manufacture of planing mill products into lengths of odd feet as well as even. It would require the yearly growth of timber on approximately 30,000 acres of average timber land to produce the amount of lumber which this annual waste represents. The manufacturer is convinced that the waste is unnecessary. His greatest trouble now lies with a similar conviction on the part of the consumer, that odd lengths can be used as economically as even lengths.

## COST OF STREET LIGHTING AND CLEANING IN LARGE CITIES.

Many interesting comparisons appear in the U. S. Census Bureau's special annual report on the statistics of the 158 cities having a population of over 30,000 each for 1907.

The section devoted to the subject of street lighting includes payments for expenses of street lighting per acre of land area and per capita, lights classified by kind, number, candle power, price per light per year, number of hours lighted per year, and average number of each kind of lights to each 100 miles of streets.

The cities with the highest per capita payments for lights were Yonkers, New York ($1.59), and Los Angeles ($1.37); and those with the largest payments per acre of land area were Hoboken ($35.03), and Boston ($32.00). Owing to the great length of their unimproved streets, the average number of lights to 100 miles of streets is very small in some cities. Of the cities using Welsbach lights, largely in the residence districts, Boston leads in the number used in proportion to street mileage, followed by Washington, St. Louis, Cleveland, New York, and Baltimore.

In comparison with similar statistics for 1905, it is interesting to note that the flat flame gas lamp is fast disappearing from use, the per cent. of decrease in number reported amounting to 43.7. This decrease has been offset by a large increase in the number of Welsbach, incandescent, and arc lights.

### STREET CLEANING COST IN 1907.

Street cleaning cost New York City in 1907, $6,941,912, though a portion of the cost of refuse disposal is included in this amount. The city next in rank was Philadelphia, which paid less than a million dollars for maintaining its street cleaning department.

Cities of over 300,000 population with a small expense for street cleaning were Milwaukee ($129,380), New Orleans ($138,993), and Buffalo ($189,683). The cities with the largest areas cleaned at least once a week were New York, 25,312,729 square yards, Philadelphia, 17,270,034 square yards, and Buffalo, 12,736,158 square yards. New Orleans had the smallest such area for cities of over 300,000 population, or less than one million square yards.

Nearly all of the area in New York, Chicago, and San Francisco subject to regular cleaning was swept by hand, while most of that in Pittsburg, Detroit, Boston, and large areas in Philadelphia, Buffalo, and Washington were swept by machine.

In Buffalo, St. Louis, Cincinnati, and Detroit large areas were cleaned by flushing, though this method in Buffalo was only an experiment and was continued for only two weeks. In comparison with similar figures for 1905, the area regularly cleaned by flushing shows a large increase.

### WATER SUPPLY SYSTEMS.

Of the 158 cities reported, 117 owned water-supply systems whose estimated value at the close of 1907 was $647,334,495. The revenue receipts from the public amounted to $52,831,096 and the actual expenses of operation to $21,231,273. The excess of receipts over operating expenses was, therefore, $31,599,823, nearly two-fifths of which was consumed in payment of interest on the outstanding debt. The remainng three-fifths was apparently net profit, but it is impossible to argue from this result that municipally owned water-supply systems are exceedingly profitable. Cities owning their water works do not receive taxes from them, and in few cases charge off a sufficient amount for depreciation. The report states that the financial results indicate, when these factors are taken into consideration, that few systems are operated at great profit while some are conducted at an actual loss. Some cities, however, aim to furnish water to their citizens at cost, and it is

possible that in such cities water rates are lower than they would be if the water system was owned by private parties.

COST OF CITY GOVERNMENTS.

In the U. S. Census Bureau's special annual report for 1907 on the statistics of 158 of the largest cities, which is in press, it is shown that the per capita running expenses of the government in 148 of the largest cities increased from $13.36 in 1902 to $15.91 in 1907. There has been a progressive increase in nearly every department of the government. The per capita increase in the fire department was from $1.33 to $1.61; in the health department from $0.22 to $0.29; in charities and corrections from $0.86 to $1.06; and in education from $3.85 to $4.70.

Of special interest in a comparison of the general expenses of the cities are payments for the maintenance of the health department. In several cities the state maintains a dispensary or health bureau, but in most cities nearly all the expense of the care of the public health is borne by the city alone. New York paid $1,691,560 for the maintenance of its health department, or more than 6 times as much as any other city. The other cities paying more than $200,000 for the maintenance of this department were Chicago ($261,614), Philadelphia ($253,709), and San Francisco ($240,198).

Cities of over 300,000 population with notably small payments for their health department were Detroit ($32,087), Milwaukee ($40,417), and Buffalo ($44,358). In the smaller cities the large expenditures of Los Angeles and Oakland, California, reflect payments for the suppression of the Bubonic plague.

The payments for schools, libraries and art galleries of the cities considered were 29.6 per cent. of the total running expenses of the government. Of the cities of over 300,000 population, the percentage spent for education was highest in Cleveland, Ohio (33.1); in cities of from 100,000 to 300,000 population the highest percentages were in Scranton, Pa., (51.5), and Seattle, Wash., (46.2); in cities of from 50,000 to 100,000 population, in Salt Lake City (48.2), and Des Moines, Iowa (46.3), and in the smaller cities, in Topeka, Kan., (54.5), and Lincoln, Neb., (53.5). Payments for outlays are not included in the above computations.

## GYPSUM IN CALIFORNIA.

REPORT BY THE UNITED STATES GEOLOGICAL SURVEY.

The growing use of gypsum as wall plaster (hard plaster) and in cement, as well as for minor uses, such as in stucco and as a fertilizer, has created a large demand for knowledge of gypsum deposits. In most States such knowledge is more easily obtained than in California, where the gypsum deposits are largely in long stretches of sparsely inhabited regions in the nearly arid territory along the east side of the Coast Range and in the Mohave and Colorado deserts.

Little has been published about these deposits, and accurate information concerning them is not easy to obtain. The Geological Survey has just published as Bulletin 413 a report by Frank L. Hess entitled "A reconnaissance of the gypsum deposits of California." According to Mr. Hess the gypsum deposits of the State may be divided into four classes—efflorescent deposits, periodic-lake deposits, interbedded deposits, and selenite, or crystallized gypsum veins. Of these all except the fourth class—the veins—may locally be of value.

Mr. Hess states briefly the character and origin of the deposits and describes them in detail, giving also analyses or partial analyses of many specimens.

The report contains a section by George Steiger on errors in the chemical analysis of gypsum.

Bulletin 413 can be had free of cost by applying to the Director, United States Geological Survey, Washington, D. C.

## LUBRICATION AND LUBRICANTS.

(Collated from the article by Charles F. Mabery, Professor of Chemistry, Case School of Applied Science; *Iron Age*, January 20, 27, 1910.)

NEXT to the conservation of the world's fuel supply there is probably no subject of greater importance in the manufacturing world than the control of waste power caused by imperfect lubrication and needless friction. Notwithstanding the increasing interest in more economical methods the immense losses from this source are scarcely appreciated. Writing on this subject, Archbutt states that 40 to 80 per cent. of the 10,000,000 H.P. used in Great Britain is spent in overcoming friction, and much of this is lost by imperfect or faulty lubrication. The conditions are probably worse in the United States on account of the cheapness of fuel, but it is safe to say that from 10 to 50 per cent. of the power employed is lost. Experts frequently find a loss of 50 per cent. or more in large factories spending thousands of dollars annually for lubrication.

In the preliminary study of the conditions upon which the results described in this paper depend, the ordinary grades of babbitt were found much too soft and yielding, under the necessary conditions of speed and oil feed, for such loads as 100 or 150 pounds per square inch of bearing surface. A very hard alloy was necessary, and one composed approximately of tin 90 per cent., copper 2 per cent., and antimony 8 per cent. gave satisfactory results. Then to maintain such conditions of load and speed that any oil could be broken down at any moment, it was found necessary in order to maintain a high degree of permanent evenness to repeatedly machine the journal and bearing to mechanically true surfaces. If such precautions be essential in precise quantitative observations, similar precautions are evidently necessary in factory operations.

Before the introduction of petroleum products the manufacturer was little concerned with the viscosity and other physical constants of lubricants, for with simple oils or greases of definite composition he knew their respective lubricating qualities. Then imperfect lubrication was of less consequence, for the prices of products were higher and competition less severe than

now. Then the principles of friction and the importance of its control were imperfectly understood. In manufacturing operations, transmission or transportation, modern high speeds and excessively heavy loads had not to be considered.

HEAVY LUBRICANTS.—A new era in lubrication began with the discovery that heavy hydrocarbon oils possessed viscosity, durability and stability under varying conditions of speed and load. The lack of knowledge of the hydrocarbons of which the lubricating oils were composed, and arbitrary methods of refining, delayed the production of suitable lubricants. Even now no fundamental changes have been made other than the introduction of heavier hydrocarbons from crude oil territory recently developed. Pennsylvania crude oils, of the general composition $C_nH_{2n+2}$ have always yielded excellent light spindle-oils, mostly the hydrocarbons $C_nH_{2n}$ and $C_nH_{2n-2}$. But such oils have not the body requisite for lubricants for heavy loads and cylinder friction. This need led to the compounding of petroleum products with rape or castor oils and animal oils or greases, and manufacturers grew to believe that no other products would answer. But the heavy lubricants, carefully distilled and treated, derived from Texas and California petroleum, are well adapted and are widely used for bearings and cylinders. It has been realized that the ideal would be a solid lubricant embodying the desirable qualities of the liquid products with a superior wearing quality, and a low coefficient of friction, and readily convertible to a form conveniently applicable to the various journals and bearings. Soapstone, asbestos, natural graphite, etc., do not entirely possess these fundamental properties. Greases compounded with graphite are useful on low speed bearings and under heavy work. On cast-iron bearings natural graphite is excellent, acting as a surface evener of the porous metal; but on finer surfaces care is necessary that it should not clot and scratch or abrade the journal or bearing. Graphite has the desirable unctuous quality and great durability, when very pure and finely divided. Whether, in the deflocculated form, the ultimate molecules or atoms have a freedom of movement analogous to that of liquid molecules under stress of friction, or whatever may be the reason, it is highly unctuous.

GRAPHITE.—Dr. E. G. Acheson has produced an ideal solid lubricant in his deflocculated graphite, which is more unctuous

than ordinary graphite and remains suspended in water and oils under certain conditions. Owing to its power of forming coherent films on journals, its wearing qualities and its ease of application, it is an efficient lubricant.

If a substance which contains non-volatile carbon is subjected to the high temperature of the electric furnace, all the other elements are readily volatilized and only Acheson graphite remains. The unctuous graphite, which is formed in the production of carborundum, is leafy in structure, coherent, and greasy or unctuous to the touch, is segregated and not readily disintegrated. Deflocculated graphite, obtained from coal or coke alone, is also highly unctuous, but very pulverulent and capable of extreme subdivision. It is readily deflocculated and when mixed with water is commercially known as 'aquadag,' when mixed with oil as 'oildag' (aqua- or oil-Deflocculated Acheson Graphite).

Under proper conditions deflocculated graphite remains suspended in water, and owing to its extreme fineness a very small amount so suspended, not over 0.35 per cent., serves as an efficient lubricant. It is remarkable that such a small quantity is readily distributed by the water between a journal and bearing, under a load of 70 pounds per square inch of bearing surface, and that it maintains an extremely low coefficient of friction under high-speed conditions.

BEARING MATERIALS.—The metals composing journal and bearing have considerable influence on the question of lubrication even with the best lubricating film intervening. Cast-iron, steel, bronze, and babbitt alloys are generally used. Extreme care is necessary with cast-iron bearings in high-speed work. In the accurate adjustment necessary in machine testing of lubricants, it has proved impossible to prevent injury to the journal when using a cast-iron bearing, nor is bronze altogether satisfactory. Properly selected babbitt on a steel journal seems the most satisfactory. As stated before for satisfactory lubrication both journal and bearing must be machined to true surfaces, kept smooth, scratches worked out and bare spots avoided. No factory supervision affords more desirable returns than constant, skilled attention to the condition of journals and bearings. Lubrication is the reduction of friction to the lowest percentage of the power used. A lubricant is an unctuous body that forms

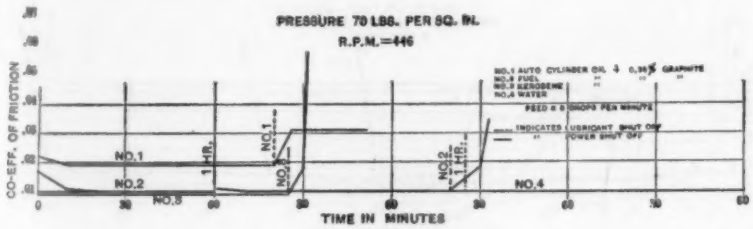
a continuous, coherent, durable film capable of holding apart rolling or sliding surfaces, and interposing the least possible resistance itself. The economic problem depends on the use of such lubricant under suitable conditions.

LUBRICANTS CLASSIFIED.—Commercial lubricants are water, oils, greases, and solids. Oils include light spindle, heavy engine and cylinder products,—either unmixed petroleum hydrocarbons, or mixtures of these with some one of the vegetable or animal oils, or with tallow or grease. The greases are generally classified according to their consistency, dependent on the proportion of lime or soda soaps mixed with a hydrocarbon oil as a carrier. Water has no oiliness, but under certain conditions is found to make the surfaces of cylinders extremely smooth and thus reduces friction. A practical knowledge of hydrocarbon lubricants should include both a knowledge of the crude oil from which it is prepared and the methods of refining. The best products are obtained by processes that leave the hydrocarbons essentially of the same composition that they had in the crude oils, but when the distillation causes decomposition the products are inferior. Improper refining can be detected by simple tests for the presence of free acid or free alkali, sodium sulphate or sodium salts of organic acids—all of which may be injurious to metallic surfaces. One of the greatest difficulties in refining is to treat with just sufficient caustic soda to remove acids and not to introduce an excess which will form an emulsion. The best refined oils are those that contain a minute trace of alkali.

LUBRICANT TESTS.—The ordinary tests for lubricating oils are the determination of viscosity, specific gravity, the flash and fire temperatures. There is no accurate method of determining the oiliness or greasiness by analysis, yet it is readily distinguishable and is a factor in the efficiency of lubricants. Authorities differ as to the most efficient methods of testing lubricating oils. Redwood thinks viscosity is the best guide to lubricating value, on account of the close relationship between viscosity and the laws of friction of liquids. As he failed to obtain satisfactory results with any friction testing machine at his disposal, he concluded that their indications are misleading. He cited the lack of agreement between the work of Ordway and Woodward, with an apparatus constructed to apply pressures of 40 pounds per square inch, and that of Tower carried out under

pressures of 100 to 600 pounds per square inch in an oil-bath system of lubrication, and the opinions of others on these results, to show that the conditions did not approximate those of actual practice. Hence he relies upon viscosity as the most valuable test of lubricating quality at our disposal. The value of viscosity is recognized, but all do not agree as to its practical reliability. Archbutt considers oiliness or greasiness nearly as important. He states that at very low speeds the friction of a journal should be proportional to the viscosity of the oil, but at high speeds, and therefore increased temperature, the relation of friction to speed ceases and the viscosity is diminished with a proportional change in the carrying power of the journal. He holds that oiliness is of especial importance under heavy loads and high speeds. Hurst maintains that the test of an oil from a

FIG. 2.



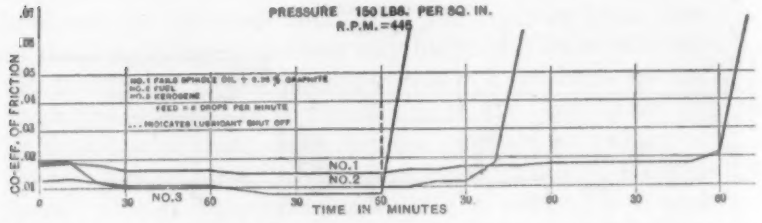

Curves of friction with varying viscosity of lubricant—bearing pressure, 70 lbs. per square inch.

journal under the practical conditions of its use, shows conclusively its adaptability to such use.

THE CARPENTER LUBRICANT TESTER.—The principal observations in mechanical tests are the effects of speed, load, temperature, and the frictional effects due to viscosity and oiliness; the quality of the oil is measured by the frictional resistance, the temperature and the endurance of the oil film. The machine devised by Prof. Carpenter, used during the past year in these investigations, has fulfilled all requirements in tests of light and heavy oils, greases and graphite, owing to its sensitive adjustment, durable efficiency, and its wide range of possible tests. The machine has an accurate adjustment for recording the speed, and a long lever-arm with a Vernier attachment graduated to tenths of a pound, for recording the friction. The load is applied by a powerful spring, worked by a cam and lever, up to 6000 pounds total load.

The projected area of the bearing used is approximately 8 square inches; the journal is about 3 inches in circumference and nearly 1 foot long. A cast-iron frame babbitted and machined to a true surface was used. Even after careful machining continuous frictional work was necessary on the babbitt surface to reach the proper conditions of constant results. When satisfactory results were once obtained there was little difficulty in keeping the surfaces of the hard form of babbitt in suitable condition. A thermometer was inserted in a hole in the bearing which extended close to the journal. Tests made at steam temperature, 210° F. (*sic*), were carried out in a hollow cast-iron babbitted bearing, with steam attachments for maintaining the desired temperature. The lubricant was run in from a sight feed cup through a small hole close to one side of the

FIG. 3.




Curves of friction with varying viscosity of lubricant—bearing pressure, 150 lbs. per square inch.

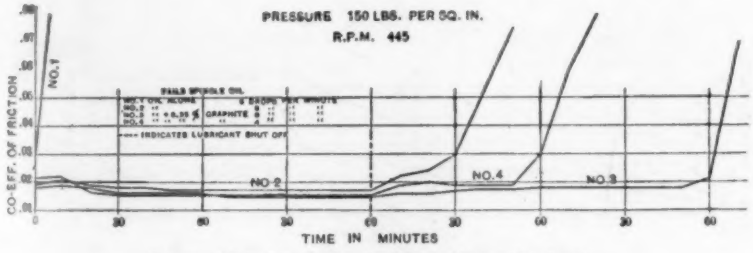
bearing, with careful regulation of the flow for proper adjustment of the feed. Two channels or grooves are run diagonally across the babbitt face from the inlet hole to allow of equal and even distribution of the lubricant; these channels must be carefully guaged for an even flow, or dry spots or streaks appear on the journal accompanied by a sudden greatly increased friction as indicated on the friction bar. This detail requires careful and constant attention, for on it depends the continuous regularity of the friction curve. The journal is partially exposed to allow the observation of the formation of the film, its comparative thickness and any irregularity due to an imperfect journal or bearing, or improper lubrication.

THE CASE SCHOOL TESTS.—Accurate testing of the mechanical efficiency of oils presented an extensive field of labor as there are no general standards of comparison under any con-

ditions of operation. Such constants must necessarily be based on arbitrary data, nevertheless if they are accurately determined on a standard machine, with the conditions of the journal and bearing selected, the load and speed constants on this machine may be readily ascertained on any other equally efficient machine. These tests must be performed with a scientific accuracy of exact quantitative observations and with close supervision of all details. The conditions should be as close as is practicable to factory conditions.

The results obtained on water, kerosene and fuel oil as vehicles of graphite present novel and interesting features. Water alone serves as a lubricating film in steam cylinders, but since it is of no value on journals, the lubricating value of aqueous suspended graphite must be wholly due to the graphite.

FIG. 4.




Curves of friction of oil and oildag with varying feeds.

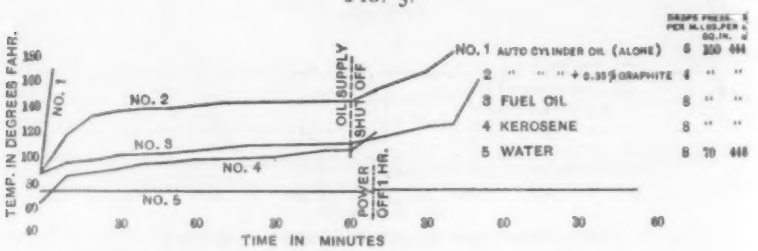
The same is true of kerosene and fuel oils which alone are practically devoid of lubricating quality.

To test the effect of varying viscosity in lubricants and at the same time the lubricating quality of deflocculated graphite, tests were made with water, kerosene, a fuel oil and an auto cylinder-oil, each carrying 0.35 per cent. of graphite. The results are shown by the curves in Fig. 2, in which the speed is maintained at 446 r.p.m. and the load at 70 pounds per square inch. Frictional load and temperature were observed at ten-minute intervals. On the chart (Fig. 2) the time is given in half-hour limits and the coefficient of friction in hundredths of a unit. The curve for water and graphite is practically a straight line, with scarcely any variations of the 4 hours shown. The test continued 15 hours with the same result. There were several stops indicated by a dotted line on the chart; but there was no

change in the direction of the curve by stopping and starting. Curve No. 3 for kerosene oil with graphite is also a straight line showing a very slightly lower coefficient than water. The curve for fuel oil and graphite is also practically a straight line and with an endurance test for 1½ hours after the oil supply was shut off; here the frictional coefficient is slightly higher than that of either water or kerosene. A similar regularity appears in the curve of the auto cylinder-oil with graphite, but the frictional coefficient is very materially higher than those of the other lubricants, which may be considered as a measure of the comparative greater internal viscosity of the auto oil.

The effect of varying viscosity in lubricants and the lubricating quality of graphite under practically the same speed, 445 r.p.m., but with a load of 150 pounds per square inch, using kerosene, a fuel oil and a spindle oil with the same proportion

FIG. 5.



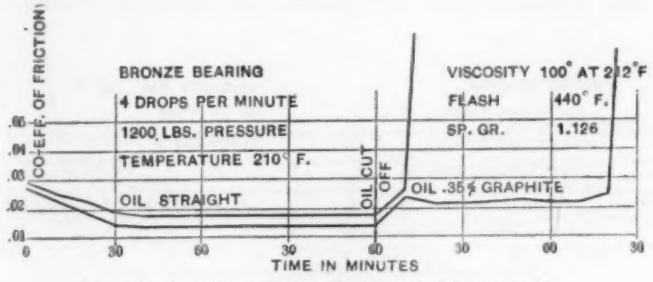

Temperature curves for lubricants of varying viscosity with or without graphite.

of graphite and the same oil supply, is shown in Fig. 3. Kerosene here shows a very slight irregularity in its coefficient, differing slightly from that in the preceding chart. Here the greater internal viscosity of fuel oil is shown by the increased friction. No doubt the fuel oil possesses a slight oiliness, enabling it at the beginning of the test to indicate a lower coefficient than kerosene. Kerosene maintains a higher coefficient for a few minutes until the continuous film of graphite has formed and reduced the coefficient to its normal condition. The spindle oil also possesses a certain oiliness, which enables it to begin the test with a coefficient that changes only slightly during the entire period, with an endurance test extending during 2 hours before the oil breaks and with only a slight increase in the coefficient of friction after the oil supply was shut off. The comparative endurance of the

three oils is also worthy of note. While under a bearing load of 150 pounds per square inch kerosene maintains an extremely low coefficient, yet the fact that it breaks immediately when the oil supply is shut off indicates that it has not the power to form a coherent graphite film, which the fuel oil has to some extent and the spindle oil has in a marked degree.

Fig. 4 is a chart of tests run at a load of 150 pounds per square inch and a speed of 445 r.p.m. It shows the effect of a variable feed when using spindle oil. In one test on the oil alone the supply was regulated to break the oil at the beginning of the test and also to perform its function as a lubricant. The effect of graphite on the lubricating quality of the oil is also shown in curves No. 3 and No. 4, No. 3 representing a feed of

FIG. 6.



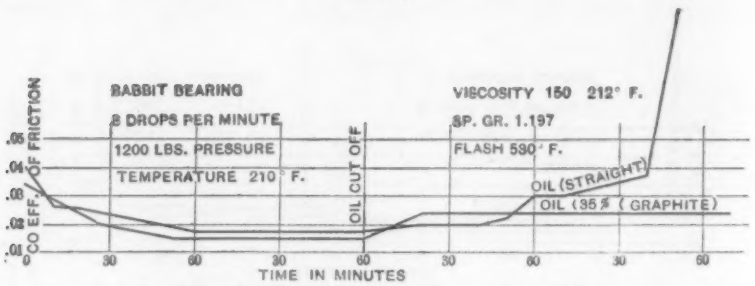

Curves for American cylinder oil with and without graphite.

8 drops per minutes and No. 4 a feed of 4 drops per minute. The diminished coefficient in curve No. 4 as compared with No. 2 represents the lubricating effect of graphite, and this effect is still further shown by the increased endurance test in curve No. 4. It will also be observed that besides diminishing friction, No. 4 is based on an oil supply due to the graphite of only one-half that of curve No. 2 of the oil alone.

In Fig. 5 the curves of temperatures are recorded in the friction tests presented in Figs. 2 and 3. The load is 150 pounds per square inch for auto oil, fuel oil and kerosene, and 70 pounds per square inch for water. Speed 444 r.p.m. for all except water, where it was 446 r.p.m. In the case of the auto oil alone there was an immediate rise in temperature corresponding to the breaking point of the oil as shown in the friction test. It is interesting to compare this temperature with that of curve No. 2

(auto oil with 0.35 per cent. of graphite) in which the temperature rises within 20 minutes to a definite point and then continues in a nearly straight line with little variation to the point where the oil supply was shut off at the end of 2 hours. Curve No. 3 of the temperatures of fuel oil and graphite also shows a very slight variation after 30 minutes, when the stable conditions of lubrication were established. A difference of approximately 25° F. is shown between the curves of the auto and fuel oils, which must represent the larger escape of energy in the form of heat from the bearing due to the greater internal resistance of the auto oil. The temperatures of kerosene with graphite, shown in curve No. 4, are approximately 10° lower than those in the fuel-oil curve, due to the still smaller resistance of the

FIG. 7.



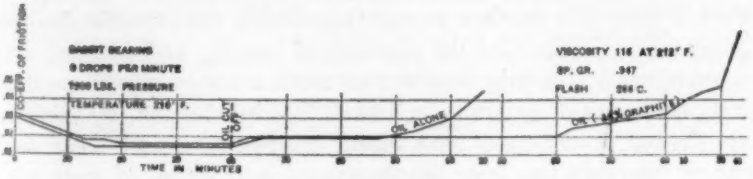

Curves for "600 W." cylinder oil with or without graphite.

kerosene. Considering the small difference between the specific gravity of fuel oil (about 35° Baumé) and that of kerosene (about 45° Baumé) the difference in temperature of these two curves is a good example of the accuracy of observation possible in these tests. Perhaps the curve of temperatures for water and graphite is the most striking on this chart; this only shows 4 hours, but actually lasted 15 hours with several stops, but the temperature at the start was the same as that at the time of interruption. This chart shows an extremely low temperature, 65° F., practically room temperature, which is never exceeded by more than 5° F. and is essentially a straight line from start to finish. The use of water as a vehicle for graphite does not interfere with the best work that graphite is capable of performing.

Considerable attention was given to the behavior of heavy

engine and cylinder oils, both plain hydrocarbon and compounded oils. A special form of bearing was constructed,—a cast-iron frame with a hollow chamber for introducing steam, and a face of hard babbitt. For some tests a bearing of similar construction but with a bronze face was used. The results were generally less satisfactory with the bronze than with the babbitt bearings, not only with heavy oils, but with others. Hard babbitt is better than bronze. Three cylinder oils, American, Galena and "600 W.," alone and with graphite were tested for their frictional coefficients and endurance, in a continuous run of 2 hours. The physical constants, especially specific gravity and viscosity, of these oils are given for comparison.

Fig. 6 is a chart of a straight hydrocarbon oil (American cylinder oil) with the bronze bearing; the lubricant was supplied at the rate of 4 drops per minute, the total pressure was 1200

FIG. 8.

Curves for Galena cylinder oil with or without graphite.

pounds and the speed 245 r.p.m. For the oil alone the curve begins at a somewhat higher coefficient than is maintained after the first half hour and then proceeds in a straight line without variation till the feed is stopped. The endurance run was doubtless shorter than it would have been with babbitt bearings, as was demonstrated by test. The curve with oil and graphite follows this very closely, but with a considerable diminution of the coefficient of friction.

Fig. 7 is a diagram of the tests with 600 W. cylinder oil alone and with graphite. This oil has a lower specific gravity and somewhat higher viscosity than the last one. The tests were run at the same total pressure and the same speed as the previous ones, but with double oil feed and with babbitt bearings. Owing to its greater viscosity the straight oil showed a considerably higher coefficient at the start and the test ran for one hour before the oil reached normal conditions, which it maintained

until the feed was stopped. After the oil was shut off the lubrication was maintained with irregularity and increased friction during 1 hour and 40 minutes, when it broke. The curve of this oil with 0.35 per cent, graphite is very similar, but it reaches normal conditions sooner, continues in a straight line till the supply is stopped, and then with slightly increased friction continues in a straight line. The marked influence of graphite is plainly apparent in these curves.

Galena cylinder oil was tested with and without graphite under the same conditions. This is less viscous but heavier than the preceding oil. To reach normal conditions the straight oil required 1 hour, and oil with 0.35 per cent. graphite, 45 minutes. After feed was stopped the oil alone broke in 1½ hours, the oil with graphite broke after 4½ hours.

CONCLUSIONS.—The results of these tests with regard to the use of graphite as a solid lubricant indicate that it can be applied with advantage in the deflocculated form. Its most characteristic effect is that of a surface evener, equalizing the metallic depressions and projections on the surfaces of bearing and journal, and endowed with a certain freedom of motion under pressure. The great efficiency of graphite in automobile lubrication, by increasing engine power, and controlling temperature and wear and tear of bearings has been demonstrated in a series of tests conducted by the Automobile Club of America. In connection with the reduction in friction the extremely small proportion of graphite necessary is notable, viz., 1 cubic inch of graphite in 3 gallons of oil.

In these observations and in all the work that has been done in this field, there is not a more impressive example of the efficiency of graphite in lubrication than that presented in the curves of friction and temperature of water and graphite, for the water serves merely as a vehicle and is completely devoid of lubricating quality; the graphite performs its work without aid and with no limiting conditions.

# SECTIONS

*Section of Physics and Chemistry.*—A meeting of the Section of Physics and Chemistry was held in the Hall of the Institute this evening (Thursday, March 3, 1910) at eight o'clock. Dr. E. Goldsmith, temporary Chairman. Thirty-seven members and visitors present. The minutes of the previous meeting were read and approved. The Chairman then introduced Mr. Arthur J. Sweet, Engineer of the Holophane Company, Newark, Ohio, who presented a communication entitled "An Analysis of Illumination Requirements in Street Lighting." The speaker discussed the problems which are met in this branch of illuminating engineering and described a series of experiments which he had conducted with a view to ascertaining the most efficient means of lighting city streets. The paper was illustrated by lantern slides. After a brief discussion the thanks of the meeting were tendered to Mr. Sweet and his paper was referred to the Committee on Publications.

There being no further business the meeting adjourned.

ALFRED RIGLING,
*Acting Secretary.*

*Section of Physics and Chemistry.*—Stated meeting was held in the Hall of the Institute, Thursday, March 10, 1910, at 8 P.M., with Dr. E. Goldsmith in the Chair. Twenty-two members and visitors were present. The minutes of the previous meeting were read and approved. Mr. Edward E. Free, Physicist of the Bureau of Soils, United States Department of Agriculture, delivered an address upon "The Phenomena of Flocculation and Deflocculation"; an abstract of the paper is appended. The address was illustrated with experiments and lantern slides.

### THE PHENOMENA OF FLOCCULATION AND DEFLOCCULATION.

By E. E. FREE.

The phenomena of flocculation are essentially phenomena of the aggregation of fine particles distributed through a dissimilar medium. The best examples are the well-known suspensions of solid particles in water, and the present paper was confined to these cases. From a study of the mechanics of suspension it was shown that in such systems the main factor affecting rate of sedimentation is the size of the particles. By changing this size, flocculation greatly influences the rate of settling. It was pointed out that flocculation and deflocculation are purely relative terms and that one should speak rather of *degree of flocculation*. The degree of flocculation may be influenced in many ways, and of these there were discussed,—(1) temperature change, (2) the addition of electrolytes, (3) the addition of organic colloids (albumin, gelatin, etc.). A brief notice was given of the theories of these effects and it was suggested that the final theory which is yet to be developed will probably include two separate explanations of the actions of added substances: (*a*) the effect of such substances on the mutual solubility relations of the suspended particles and the medium in which they float, and (*b*) the effects on the electric charges resident on the surfaces of the particles. The action of the organic colloids in preserving suspensions was explained (according to well-known theory) as due to the formation of a thin film of the colloid about each suspended particle.

The practical applications of flocculation studies were then briefly noted, and the paper concluded with a note of flocculation in gas-liquid-solid systems, especially in moist soils.

The paper was discussed; a vote of thanks was tendered the speaker for his valuable communication, and the paper was ordered published in full. The meeting then adjourned.

JOSEPH S. HEPBURN,
*Secretary.*

*Mechanical and Engineering Section.*—A meeting of the Section was held this evening (Thursday, March 17, 1910) at eight o'clock.

Dr. E. Goldsmith in the Chair.

The minutes of the previous meeting were read and approved.

Mr. Charles E. Foster of the Taylor Instrument Companies, Rochester, N. Y., then presented the paper of the evening entitled: "A New Pyrometer."

The speaker confined his remarks to radiation pyrometry. After a brief review of the history of the subject he described an instrument, which he had devised, known as the fixed-focus pyrometer. Lantern slides and apparatus were used to illustrate the subject.

The thanks of the meeting were extended to Mr. Foster for his paper. Adjourned.

ALFRED RIGLING,
*Acting Secretary.*

*Electrical Section.*—A meeting was held on Thursday, March 24, 1910, at 8 P.M. President Thomas Spencer in the Chair. The minutes of the previous meeting were read and approved. Dr. Joseph W. Richards of Lehigh University, South Bethlehem, Pa., presented a paper on the electrometallurgy of steel. The speaker reviewed the progress made in the use of electricity in the manufacture of steel and illustrated his subject with many lantern slides. After a brief discussion the thanks of the meeting were extended to Dr. Richards for his interesting paper. Adjourned.

ALFRED RIGLING,
*Acting Secretary.*

# FRANKLIN INSTITUTE

(*Proceedings of the Stated Meeting, held Wednesday, March* 16, 1910.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 16, 1910.

*President* WALTON CLARK *in the Chair.*

Present, 63 members and visitors.

Additions to membership since last report, 13.

Dr. Edward P. Hyde of the National Electrical Lamp Association of Cleveland, Ohio, read a communication on "The Physical Production of Light."

After a brief introductory statement of certain questions in physiological optics which determine the light-giving properties of radiant energy the speaker discussed the laws of radiation and the radiating properties of metals. Particular attention was given to various new methods for determining selective radiation, and data obtained by the use of these methods was presented. The subject was illustrated by lantern slides.

After a vote of thanks to the speaker the meeting adjourned.

JAMES CHRISTIE,
*Secretary.*

## COMMITTEE ON SCIENCE AND THE ARTS

(*Proceedings of the Stated Meeting, held Wednesday, March* 2, 1910.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 2, 1910.

MR. THOMAS SPENCER *in the Chair.*

The following report was presented for final action:

(No. 2465.) Dirigible Balloon, B. D. Reese. (Adopted, Edward Longstreth award.)

For first reading:

(No. 2459.) System of Automatic Telephony, Automatic Electric Company, Chicago.

JAMES CHRISTIE,
*Secretary.*

# BOOK NOTICES

CANADA, DEPARTMENT OF MINES, MINES BRANCH. Report on the Investigation of an Electric Shaft Furnace, Domnarfvet, Sweden, etc. By Eugene Haanel, Ph.D., Director of Mines. 38 pages, illustrations, plates, 8vo. Ottawa, King's Printer, 1909.

As a sequence to the reports on Electric Smelting of Iron Ores published in 1904, 1906 and 1907, the Mines Branch has just issued the report on an electric shaft furnace in operation at Domnarfvet, Sweden. The investigation was made by the Director of Mines, on the invitation of the inventors, and the results given represent the latest developments of the electric smelting of iron ores.

The report is divided into four parts. Part I deals with the Domnarfvet furnace, the trial runs witnessed by the writer of the report and the comparative costs of production of pig-iron by the furnace. The other three parts, which are more of the nature of appendices, describe: (1) a new electric furnace for the manufacture of steel, (2) the manufacture of electrodes, (3) methods of manufacturing wood-charcoal, this material being used to supply the carbon which enters into the composition of pig-iron manufactured by electric smelting.

Three full page plates, from photographs, and numerous drawings, illustrate clearly the descriptive matter of the book.

R.

LINE PHOTO ENGRAVING. A Practical Handbook on All Methods of Reproduction in Line, Grain, and Stipple. By Wm. Gamble, Editor of the "Process Year Book," x, 332 pages, 9 x 6 inches, 172 illustrations. Cloth, price in Great Britain 7/6. Percy Lund, Humphries & Co., Ltd., London, 1909. American Agents, Tennant & Ward, 122 E. Twenty-fifth St., New York.

As stated by the author, the object of the present work is to meet the uses of a book dealing exclusively with the numerous processes for the reproduction of line subjects, descriptions of which may only be found widely scattered in the pages of many volumes of photographic and photomechanical literature, and to review some of the interesting old processes which have fallen into disuse by the progress and universal use of halftone reproductions.

The author has shown rare discrimination in dealing mainly with those methods of chemigraphic reproduction which have proven their value and importance in practical application, while yet giving due consideration to those earlier processes out of which the present accepted methods have been evolved and which contain the germs of further development in various directions of possible importance.

The book presents a clear statement of the many practical details involved in the numerous processes described, all of which are very fully illustrated. The chapters on preparation of the copy for the camera, on the workrooms and their equipments, and especially on the making of the negative, will interest not only photo-engravers, but also all others who have occasion to make photographic copies of originals in line, stipple or grain. In that division is included a full account of the practice of wet-plate photography which, despite the efforts of many years to utilize dry plates, remains to this day, either in its ordinary form or in that of collodion emulsion, the only fully satisfactory method of making a negative for any of the photo-reproductive processes.

The most recent advances in the art are treated in this book, including the latest forms of "Process" cameras and other paraphernalia, and also the recently introduced mechanical devices for expediting and improving the etching process itself. A number of different appliances designed for this purpose are illustrated and described, including the American invention known as the "Levy Acid Blast Process" and the apparatus for applying it, and also the "Etch-Powdering" machine lately brought out by the same inventor for the automatic preparation of the metal plate for the etching process. The book is a handy volume, well printed, and makes a valuable addition to the literature of its subject-matter. P. E.

HYDRO-ELECTRIC DEVELOPMENTS AND ENGINEERING. A Practical and Theoretical Treatise on the Development, Design, Construction, Equipment and Operation of Hydro-electric Transmission Plants. By Frank Koester, Consulting Engineer, Assoc. Mem. Am. Inst. E. E., Member Society German Engineers (Berlin), Author of Steam-electric Power Plants. XXV × 454 pages, 10½ x 7½ inches, with 500 illustrations. Price, $5.00 net. D. Van Nostrand Company, New York: Archibald Constable & Co., Ltd., London, 1909.

The development of water power is an important component of the question of the conservation and utilization of our natural resources, now so prominently in the public mind. Some of the projects that have already been developed and are in actual operation in the several quarters of the civilized world have been without precedent in size and their successful completion has embodied a high order of originality in design and of technical skill.

A collection of this data relating to these and other modern installations is of the highest value to those interested in hydraulic power development. In this book Mr. Koester has not only collected an extensive array of data from representative plants but he has arranged it in analytical form with the several subdivisions and details of the subject in such logical order as to form a treatise covering the process of installation from breaking the ground to the erection of the transmission line and its appurtenances.

The work is divided into three parts:

Part I. Transformation of Water-Power into Electrical Energy.

Part II. The Transmission of High Tension Electrical Current.

Part III. Modern American and European Hydro-electric Developments.

The work is profusely illustrated with excellent line cuts or half-tone engravings of every feature involved in the development of the project, which is investigated in great detail, and which with the many tables of technical data included, make it of value not only as a treatise but also as a reference book.

In a treatise of this kind it is evident that a discussion of the elements of design in the structure and equipment cannot be undertaken; the author has, however, supplied a fertile source of more detailed information by a comprehensive and appropriately arranged bibliography.

The work as a whole should prove of much practical value to the student of hydro-electric practice and an inspiration to the professional engineer. L. E. P.

CANADA, DEPARTMENT OF MINES, MINES BRANCH. Report on the Tungsten Ores of Canada. By T. L. Walker, M.A., Ph.D. 56 pages, illustrations, plates, maps. Ottawa, King's Printer, 1909.

Amongst the rare metals which have recently become of commercial value, tungsten is an important example. One of its most recent applications is as a filament in incandescent lamps, in which it gives a much more brilliant light with greater efficiency than carbon. Its most important use, however, is in the manufacture of tungsten steel, to which it imparts great elasticity and tensile strength. The metal has, therefore, become particularly valuable to the manufacturers of special steels. The known occurrences

of tungsten ores throughout the world are comparatively few, which fact lends additional interest to some discoveries of scheelite (an ore of tungsten) which have been made within the past year or two in Nova Scotia. These, together with other occurrences of tungsten ores in Canada, have been made the subject of the present report, which is designed to present to those interested all the available information on these ores.

The several occurrences of tungsten ore in Canada are described in detail, and a general statement is given on the geological occurrence of the ores, chemical tests, concentration, the uses of the metal, producing mines in other countries, statistics of the world's production, etc., while a very useful bibliography of the literature on Canadian and United States occurrences is added.

R.

JAHRBUCH DER ELEKTROCHEMIE UND ANGEWANDTEN PHYSIKALISCHEN CHEMIE. Begründet und bis 1901 herausgegeben, von Prof. Dr. W. Nernst und Prof. Dr. W. Borchers. Berichte über die Fortschritte des Jahres 1905. Herausgegeben von Dr. Phil. Heinrich Danneel. Illustrated, 1049 pages, 8vo, Halle, a/S, Wilhelm Knapp, 1909.

The twelfth volume of this annual contains the usual amount of interesting and useful information for the investigator and student in the field of electrochemistry.

The work is divided into two parts,—the first containing the general scientific information a constants of nature, a review of recent literature, new apparatus, conductivity of solutions, chemical and electrical energy, polarization, radio-activity, etc.; the second part is devoted to matters relating more especially to applied electrochemistry.

It is unfortunate that editorial difficulties have made it impossible to issue the work more promptly. R.

A TEXT-BOOK OF PHYSICS. Edited by A. Wilmer Duff. Contributors: A. Wilmer Duff, Karl E. Guthe, William Hallock, E. Percival Lewis, Arthur W. Goodspeed, Albert P. Carman, R. K. McClung. xi + 698 pages, 8 × 5½ inches with 525 illustrations, second edition revised. Price, $2.75 net. P. Blakiston's Son & Co., Philadelphia.

There can be little question of the wisdom, in the production of a book of this kind, of subdividing the task by the co-operation of a staff of specialists. The early appearance of a second edition is an indication of the success of this plan and that it has found an extensive sphere of usefulness.

A few changes have been made in the text and these relate to arrangement and not to the addition or suppression of subject-matter.

The authors have reason to contemplate with satisfaction the results of their collaborative plan of treating this extensive subject. L. E. P.

# CURRENT TOPICS

BROWNIAN MOVEMENT OF ROTATION. The granules affected by the Brownian movement revolve irregularly around themselves while at the same time they displace each other. This is easily explained by considering it as the effect of molecular shocks on the granules; shocks whose action at each instant is equivalent to the combination of a couple and a force which makes the granule revolve as well as displacing it. To be more precise, at a given temperature, each granule is agitated in such a way that its energy of rotation and its energy of translation have the same mean value, moreover independent of the size of the granule and equal to the mean energy of translation of an isolated molecule.

With regard to these relations, Einstein has shown that the rotation of a spherical grain of radius $a$ placed in a fluid of viscosity, $\zeta$, and of absolute temperature $T$, should satisfy the equation,

$$\alpha^2 = \tau \frac{RT}{N} \frac{1}{4\omega\zeta a^3}$$

Where $R$ is the constant of perfect gases, $N$ is Avogadro's constant (number of molecules per molecule-gramme) and $\alpha^2$ the mean square of the rotation in a time $\tau$ relatively to an arbitrary axis. Experimentally it has been shown that for a sphere of 11.5 M. diameter, the angle of rotation is 14.5,° and according to the mathematical formula 14°. This agreement is remarkable. (M. Jean Perrin, *Moniteur Scientifique*, Jan., 1910.)

COBALT ALLOYS. E.M.F. curves are given for alloys of cobalt with tin, antimony, bismuth, lead and copper. They indicate the existence of the compounds, CoSn, CoSb, and probably, though rather indefinitely, $CoSb_2$. The curves for the alloys of lead, bismuth, and copper with cobalt show the existence of solid solutions, and the approximate limits of solubility. (F. Ducelliez, *Comptes Rendus*, 1910, 150, 98 to 101.)

ELECTRIC MOTIVE POWER. A remarkable record has been made by the Edison Illuminating Co. of Brooklyn. In the short space of four months the company has displaced no fewer than thirty-eight gas engine plants ranging from 40 H.P. down to 2 H.P. In all these places motors of varying capacity are now installed, and a comparison of the relative cost of operation is largely in favor of the electric motor. In addition to the impor-

tant matters of cleanliness, absence of noise and smell, ease of starting, absence of fire risk, and all the other advantages of the electric drive, the motor permits the owner to use small quantities of electricity when required as against the necessity of running a gas engine at practically constant speed whether or not a load is being carried, while in the larger units the inability of the gas engine to operate elevators and similar machines requiring high-starting torque has been a point in favor of electric service. Current is supplied in Brooklyn on a maximum demand system, under which the charge is 10 cents per kw. hour for the first 25 hours per month use of the maximum demand; 5 cents per kw. hour for the second 25 hours per month use; and and 3 cents per kw. hour for all energy furnished in excess of 50 hours per month use of the maximum demand. When the portion of the bill figured at 3 cents per kw. hour exceeds $25, the discount is 5 per cent., when the amount is $50, the discount is 10 per cent.; for $200 the discount is 20 per cent., for $400 it is 40 per cent., and 50 per cent. when it is $1000 or over. (*Elec. Eng.*, N. Y., Jan., 1910.)

ELECTRODE LOSSES IN ELECTRIC FURNACES. An endeavor to find by experiment mean conductivities which should be inserted in the received formulas in order to find the best ratio of length to cross-section of an electrode.

The arrangement of the electrodes is shown in Figs. 1, 2 and 3. In Fig. 1, let *ab* be a rod of the electrode material to be tested, embedded in a heat insulating material *I*, except the

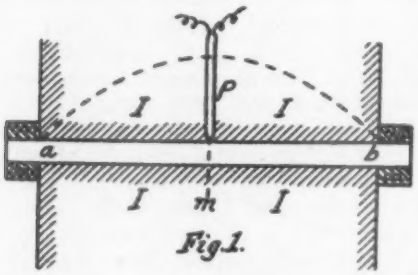


Fig. 1.

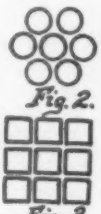


Fig. 2.


Fig. 3.

ends which are water-jacketed or otherwise cooled and kept at a constant, known, relatively low temperature. The insulation assumed to be perfect. Cross-section of rod is *S* square inches, length of insulated part is *L* inches.

Pass a relatively large electric current longitudinally. The temperature of the insulated part will rise, the highest being in the middle section *m*, and falling towards both ends to the temperature of the water-cooled ends. A pyrometer *P* is introduced at the middle point.

Pass a constant current till a stable state is reached, *i.e.*, until the pyrometer ceases to rise, then all the heat electrically generated flows out only at the two ends. Now measure the temperature at the centre, and at the water-cooled ends, the current and the voltage. The product of the current + the voltage gives the heat flow in watts, $W$, which is leaving at the two terminals. It is not necessary to measure the heat absorbed by the cooling water as this heat flow is determined more readily and probably far more accurately by means of an ammeter and voltmeter.

The heat conductivity of this material is determined by the formula $K=0.02986\ \frac{WL}{TS}$, in which $K$ is the mean heat conductivity in gramme calories per second per square inch for 1° C. per inch, and $T$ the difference in temperature in centigrade degrees between the maximum at the middle and that at the water-cooled ends.

From the same readings of volts $E$ and amperes $C$ the mean electrical restivity for that same range of temperature is calculated from the formula

$$r = \frac{E\,S}{C\,L}$$

in which $r$ is the restivity in ohm-cubic-inch units.

It is assumed that the insulation is perfect. This may be accomplished without appreciable error by surrounding the test rod by a tube of the same or similar material, which is electrically insulated from it, and is also heated by a current to the same temperature in the middle and cooled to the same temperature at the ends. The heat gradients in the test rod and in the enclosing tube will then be the same, hence no heat will leave the embedded part of the test rod except the very slight amount which flows longitudinally through this insulating and non-conducting material and escapes at its outer ends. If this insulator is made very thin, just thick enough to insulate electrically, and the rod be relatively large in cross-section and long, the heat lost through the insulator may be made extremely small, if the material is loosely fibrous or granular, so that the actual heat insulation is practically due to the air in the interstices. Moreover one-half of this small heat comes from the tube and only one-half from the test rod.

Or instead of a tube, surround the test rod with a number of similar rods, embedded in the same insulating material and arranged parallel to, and as near as possible to, the test rod, as shown in Figs. 2 and 3. The ends of each are water-jacketed like the test rod. These can all be connected electrically in series with each other and with the test rod, so that the same current heats them all. If they are all of the

same size and material, the temperature can be safely assumed to be practically the same in them as in the test rod, and then a second pyrometer on the outer row of rods is unnecessary.—(Carl Hering, *Elec. Eng.*, N. Y., Jan. 9, 1910.)

FERRO-SILICON. Numerous accidents have been caused in the last few years by the escape of poisonous and explosive gases from consignments of the so-called high-grade ferro-silicon produced in the electric furnace. These accidents have generally occurred during the transport of the ferro-silicon by water, in various countries, on vessels of different nationalities, while in almost every instance the ferro-silicon carried has been the product of a different manufactory. Ferro-silicon, especially of grades containing from 40 to 60 per cent. of silicon, is found invariably to evolve considerable quantities of phosphoretted hydrogen and a less amount of arseniuretted hydrogen. A certain amount of the gas evolved is occluded in the alloy. Certain grades of ferro-silicon, notably those that contain about 33 per cent., 50 per cent., and 60 per cent. silicon, corresponding possibly to the formulæ FeSi, $FeSi_2$ and $FeSi_3$ respectively, even when manufactured from fairly pure constituents, are brittle and liable to disintegrate spontaneously, especially the 50 per cent. grade. The evolution of poisonous gases is greatly increased by the action of moisture or of moist air, under the influence of which phosphoretted hydrogen is generated from calcium phosphide, which is formed from the calcium phosphate present in anthracite and quartz, at the temperature of the electric furnace. If spontaneous disintegration of the alloy also occurs, much larger quantities of gas would be given off from such friable and unstable material, other things being equal. The greater or less tendency of a given sample to evolve poisonous gases, and a rough estimate of their probable amount, may be arrived at by the use of test papers prepared with silver nitrate. There is no evidence that low-grade ferro-silicon, of 10 to 15 per cent., produced in the blast-furnace, has ever caused similar accidents to those known to have been produced by the high-grade electrically produced alloy. Blast-furnace ferro-silicon does not evolve poisonous gases even in presence of moisture. Grades produced in the electric furnace up to 30 per cent. and probably also those of 70 per cent. or over, appear to be practically innocuous. As the use of ferro-silicon of grades between 30 and 70 per cent. is apparently not essential in metallurgical operations, with the possible exception of basic steel manufacture, it would appear advisable to discontinue the production of alloys ranging between these grades. The proprietors of iron and steel works using ferro-silicon, will protect their work people and act for the public benefit, by restricting their orders to grades not exceeding 30 per cent., or of 70 per cent. and over, according to their special requirements. But as, pending international agreement

on the question, intermediate percentages of ferro-silicon will doubtless continue to be manufactured and sold, the issue of special regulations by the Board of Trade will be necessary, to obviate, so far as possible, the chance of further accidents in the transport of this material. *Inter alia*. these regulations should require a declaration of the nature, percentage, date of manufacture, and place of origin of any such consignment.

*Suggested Regulations* as to precautionary measures in connection with the storage and transport of ferro-silicon.

1. Ferro-silicon should not be sent out from the works immediately after manufacture, but after being broken up into pieces of the size in which it is usually sold, should be stored under cover, but exposed to the air as completely as possible, for at least a month before being despatched from the works.

2. Manufacturers should be required to mark in bold letters each barrel or parcel of ferro-silicon with the name and percentage grade (certified by chemical analysis) of the material, the name of the works where it is produced, the date of manufacture, and the date of despatch.

3. The carriage of ferro-silicon on vessels carrying passengers should be prohibited. When carried on cargo boats, it should, if possible, be stored on deck. If considered necessary to store it elsewhere the place of storage should be capable of being adequately ventilated, and such place of storage should be cut off by air-tight bulkheads from the quarters occupied by the crew of the vessel.

4. This regulation should apply to the transport of ferro-silicon on river or canal barges as well as on sea-going vessels.

5. Storage places at docks or at works where ferro-silicon is used, should have provision for free access of air, and should be situated at a distance from work-rooms, mess-rooms, offices, etc. (Report of Medical Officer Local Govt. Board, *Jour. Soc. Chem. Ind.*, Feb. 15, 1910.)

NICKEL PHOSPHIDES. Two new nickel phosphides $NiP_2$, specific gravity 4.62 at 18° C., and $NiP_3$, specific gravity 4.19 at 18° C., have been prepared by the author. Both are crystalline substances of metallic appearance. They are prepared by heating a nickel-tin alloy, containing 5 per cent. nickel with phosphorus in a sealed, evacuated Jena glass-tube to 700° C., using 1 to 4 grammes of phosphorus with 21 grammes of the alloy; the diphosphide, $NiP_2$, is isolated from the product by treatment with warm concentrated hydrochloric acid. If more phosphorus is used, this treatment leaves a mixture of the phosphides of tin and nickel, $SnP_3$ and $NiP_3$. The tin-phosphide is decomposed by heating to 360° C. under reduced pressure, and then further treatment with hydrochloric acid leaves the nickel tri-phosphide, $NiP_3$, as a crystalline residue. (P. Jolibois, *Comptes Rendus*, 1910, 150, 106–108.)

PHOSPHORUS CHLORIDE. This new chloride, $P_2Cl_4$, is obtained by the action of a silent electric discharge on a mixture of hydrogen and the vapor of phosphorus tri-chloride. It is a colorless oily liquid and smells strongly of phosphorus. Its melting point is —28° C., and boiling point about 180° C., or 95° C. at 22 mm. Bar. pressure. It oxidizes in air, fumes, and will ignite spontaneously under suitable conditions. It decomposes spontaneously in a vacuum, and more readily with the aid of heat and light, becoming phosphorus tri-chloride and other bodies of varying composition. Attempts to prepare the corresponding dibromide, $P_2Br_4$ have not been successful.—(M. M. A. Besson and L. Fournier, *Comptes Rendus,* 1910, 150, 102.)

POTASSIUM CYANIDE. An aqueous solution of potassium cyanide acts as a powerful insecticide when injected into the soil, by reacting on the calcium bicarbonate present and slowly liberating hydrogen cyanide. It possesses certain advantages over carbon disulphide, as it is slower and more thorough in its action, insects are not aware of its presence from its odor and therefore do not escape, and it has no effect on growing plants, even in strong doses, nor does it stop fermentative changes in the soil as carbon disulphide does.—(T. Mamelle, *Comptes Rendus,* 1910, 150, 50.)

$130,000,000 ELECTRIC BELT LINE. The New York Public Service Commission is now considering proposals for the construction of a circular electric subway to run all around New York. The belt, as proposed, will encircle Manhattan and the Bronx, extend under the East River to Brooklyn, and there connect with the Fourth Avenue subway now under construction; and later, when practicable, by way of Fort Hamilton and the Narrows, to Staten Island, and also by a Fifty-ninth Street cross-town link under the East River to Queens and several Long Island points. The proposed subway system is to be built in about 24 sections of about 1 mile each, and with four tracks, which will encircle the two boroughs of Manhattan and the Bronx. The cost is estimated at $130,000,000, and the promoters are Messrs. E. J. Farrell and John J. Hopkins of N. Y. (*Elec. Eng.,* N. Y., Jan. 14, 1910.)

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